LANGUAGE COMPREHENSION AND WORKING MEMORY IN ADOLESCENTS WITH TRAUMATIC BRAIN INJURY

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ABSTRACT

Children who sustain a traumatic brain injury frequently present with linguistic deficits that persist into adulthood. Relatively little is known, however, about the listening comprehension abilities of these children in their adolescent years. Secondary school education places heavy demands on listening comprehension and impairment at this level is likely to negatively impact upon academic achievement and the development of peer relationships. The present study investigated the listening comprehension performance of adolescents who suffered a traumatic brain injury (TBI) during childhood and explored factors that may influence their comprehension of advanced language forms.

Listening comprehension was examined in this study from a perspective of typical language development in adolescence as well as from a working memory theory of listening comprehension. Six adolescents with TBI and six age-matched controls, as well as a typically developing group of adolescents participated in the study. Following the establishment of normative estimates for New Zealand adolescents on measures of working memory, a battery of standardized language and memory tests were administered to examine the listening comprehension and working memory profiles in the six adolescents with TBI. A series of experiments was then conducted to further explore the performance of adolescents with TBI in comprehending proverbs, idioms, and inferences and to explore the influence of working memory demands of the tasks on comprehension performance.

Results revealed that the adolescents with TBI presented with listening comprehension impairment relative to their age-matched peers. Adolescents with TBI were, however, significantly more sensitive to increased working memory demands of comprehension tasks compared to their peers, performing better on tasks that required low working memory storage and processing demands. A working memory theory for explaining the deficits in TBI was posited. Theoretical and practical implications of the findings regarding working memory and language comprehension were discussed.

CHAPTER 1: LITERATURE REVIEW

1.0 Introduction

Traumatic Brain Injury (TBI) is a serious medical disorder with costly long-term effects. For those who survive the initial injury, most will present with a cognitive-communication deficit (Beukelman & Yorkston, 1991). The prevalence of people discharged from hospital with a communication disability resulting from TBI is increasing as advances in medical care ensure a greater number of people survive the initial injury. In New Zealand, the incidence of people discharged from hospital with a diagnosis of TBI is approximately 10, 500 per year (Accident Rehabilitation and Compensation Insurance Committee on Health and Disability, 1998). It has been estimated that more than 30% of these individuals will be children (Body & Leathem, 1997).

Children who sustain a TBI frequently present with linguistic deficits that persist into adulthood (Jordan & Murdoch, 1994). However, the developing language profiles of these children, particularly through the adolescent years when advanced language learning occurs, have not been well documented. In particular, the comprehension abilities of adolescents who have incurred a TBI in childhood require examination. The comprehension demands of secondary school education stresses an adolescent's linguistic system and impairment at this level will significantly restrict academic achievement. Further, peer relationships may also be affected by the adolescent's inability to use and understand language forms such as figurative language that arise in social contexts.

The aim of this thesis is to examine the comprehension profiles of adolescents who have sustained a TBI during childhood and to explore the nature of their comprehension deficits.

1.1 Adolescent Language Development

Adolescence, the time between puberty and adulthood, is characterized by change. The most obvious changes are physical, however cognitive and neuronanatomical changes have also been described (Anderson, 1998; Anderson, LaJoie & Bell, 1995; Levin et al., 1991; Nippold, 1988; Thatcher, 1991, 1992). Developing aspects of cognition (including language) may be particularly susceptible to TBI (Dennis, 1989; Ewing-Cobbs, Fletcher & Levin, 1987). Yet studies examining linguistic outcomes following TBI have frequently grouped children and adolescents together (e.g. Asarnow, Satz, Light et al., 1995; Dennis & Barnes, 2000). Such grouping restricts our understanding of the impact of brain injury on the continued linguistic growth that is evident in typically developing adolescents. Further research is required to document the linguistic skills of adolescents separately from the linguistic skills of young children with TBI.

Accurate identification and assessment of linguistic deficits in adolescents with TBI necessitates in-depth knowledge of the language development in a typical adolescent population. Anderson (1998) demonstrated the important contribution that knowledge of normal development has in data interpretation. When performing a linguistic task that had been designed for adults, adolescents with TBI scored poorly, however, their performance was not lower than typically developing adolescents. It was concluded that although the test could be used with an adolescent population, normative data and understanding of typical adolescent behaviour was essential. Likewise, language tests designed for young children are not suitable for assessing the later developing language forms that may be affected by TBI.

In order to choose appropriate assessment tasks that target later-language forms, it is important to understand the linguistic changes that take place in adolescence. Of interest in this thesis are the changes that occur in language comprehension: namely, comprehension of advanced syntax, vocabulary, and figurative language.

1.1.1 Syntactic Development

Understanding of advanced syntactic structures is important to assess in adolescents with TBI. Although research based on narrative discourse studies has suggested children with TBI do not produce syntactic errors in spoken language (Chapman, 1997), their comprehension of advanced syntactic forms must be considered. Adolescents are likely to be exposed to complex syntactic forms in school texts and lectures and difficulty comprehending such structures will affect their academic performance. The narrative discourse tasks used by Chapman may not have facilitated complex syntactic forms. Later developing language forms, such as low-frequency structures are more likely to be evident in persuasive narratives, expository discourse and formal written language contexts (Crowhurst, 1980; Crowhurst & Piche, 1979; Nippold, 1998). To determine whether syntax comprehension and use is affected in adolescents with TBI, advanced syntactic development should be studied.

Development in syntax use in adolescents is characterized by longer sentences (Crowhurst, 1980; Loban, 1976), increased use of low frequency structures (e.g. appositives, passive voice, elaborated subjects) (Scott, 1988), and increased use of conjunctions (Loban, 1976). Relatively few studies have examined comprehension of syntactic forms but, those that have, show that comprehension continues to develop in adolescence (e.g. Flores D'arcais, 1978; Nippold, Schwarz, & Undlin, 1992; Robertson, 1968).

A series of Dutch studies examined the comprehension of conjunctions by children aged 7 to 12 years using a variety of tasks (Flores d'Arcais, c.f. Nippold, 1998). In the first study, children aged 7, 8, 10, and 12 years read two sentences containing the conjunctions *because*, *so that,* and *before* and determined whether the meaning was the same or different. In a second study, the same conjunctions were presented in a different task. Children aged 8, 10, and 12 years listened to a short story followed by a choice of three sentences. Each sentence contained one of the conjunctions. The children had to choose which sentence went best with the story. Mastery was not achieved in either study by any of the groups, however the older children did perform significantly better than the younger children.

To determine whether mastery occurred in adolescence, Flores d'Arcais (1978) included a control group of adults. Children aged 8, 10, and 12-years, and an adult control group were given 20 cards with a conjunction written on it. The participants grouped the conjunctions according to whether they were causal, temporal or conditional. The adults successfully performed the task but the children across all age groups performed poorly. The studies conducted by Flores d'Arcais demonstrated that understanding of conjunctions improved with age, with metalinguistic competency being acquired by adulthood.

Understanding of conjunctions extracted from children's textbooks also demonstrated that adult understanding was not achieved prior to adolescence. Robertson (1968) tested conjunctions that occurred in Grade 4, 5, and 6 students' textbooks. The children (n = 402) read an incomplete sentence containing a conjunction and chose the appropriate ending for the sentence out of four possibilities. Accuracy scores ranged from 57% to 75% for Grades 4 and 6 respectively. Grade 6 children did not demonstrate mastery for understanding conjunctions even though the materials used were considered age-appropriate.

Lexical cohesion is another measure of syntactic growth in adolescence (Nippold, 1998). Improved lexical cohesion is determined by increased use and understanding of adverbial conjuncts (Nippold, 1998; Nippold et al., 1992; Scott, 1984). Adverbial conjuncts are words that connect clauses or sentences by implying a relationship (e.g. *furthermore, alternatively*, *however*) (Quirk & Greenbaum, 1973). Adverbial conjuncts might also be used to change topics (e.g. *anyway, by the way*) or express a difference of opinion (e.g. *on the other hand*) (Nippold, 1998). Scott (1984) looked at production of adverbial conjuncts and disjuncts (e.g. *frankly, unfortunately*) by children. Conversation analyses were conducted with 114 children aged 6, 8, 10, and 12 years. The 10- and 12-year-old children produced three times as many conjuncts as the 6-year-old children. Growth in the older children was reflected, not only in frequency, but also in the variety of conjuncts used. At six years of age, there was evidence of only six conjuncts used, whereas by age 12, fifteen different conjuncts were used. Compared to conjuncts, disjuncts were used less frequently by all children. Additionally, there was a significant difference in disjunct use across age with 78% of the items occurring in the 10- and 12- year-old sample. Scott (1984) concluded that disjunct use was relatively underdeveloped in children between 6 and 12 years of age. In order to understand whether development continued into adulthood, Scott (1984) compared the results to adult data. The researcher concluded that 10-and 12-year olds would have to produce three times as many conjuncts to match the adult production. Scott's (1984) research suggested that development does continue up to adolescence, however development through later adolescent years was not examined.

To explore development across the range of adolescence, Nippold et al. (1992) examined comprehension and use of adverbial conjuncts through adolescence and into adulthood (Nippold et al., 1992). Ten adverbial conjuncts ranging from common conjuncts (e.g. *however*) to less common (e.g. *contrastively*) were studied. The sample consisted of 120 participants aged 12, 15, 19 and 23 years. In the production task, participants formulated a sentence using an adverbial conjunct. The comprehension task involved reading a paragraph and selecting the conjunct that was appropriate to the meaning of the paragraph. The results demonstrated that performance on both use and understanding of adverbial conjuncts increased with age. Comprehension was superior to production with comprehension scores ranging from 50% to 94% correct and production scores ranging from 45% to 85%. Significant differences were found among the 12-, 15-, and 19- year-olds on the comprehension task, with the greatest difference occurring between 12 and 15 years. Results from the production task suggested the greatest growth in production occurred between 15 and 19 years, however even the 23-year-olds did not reach mastery.

Identification of changes in syntax comprehension through adolescence reinforces the need to consider normal language development when assessing outcomes following childhood TBI. Although more research is needed, assessment tools that include later-language forms should be included in a test battery designed for assessing language comprehension in adolescents with TBI.

1.1.2 Vocabulary

Vocabulary continues to develop throughout adolescence and into adulthood. Adolescents continue to acquire new words and develop more complete understanding of words already learned (Nippold, 1998). Types of words that develop through adolescence include words with multiple meanings (Nippold, Cuyler, & Braunbeck-Price, 1988), adverbs (Hoffner, Cantor & Badzinski, 1990), metaliguistic and metacognitive verbs (Nippold, 1998), and factive and non-factive verbs (Nippold, 1998).

There is rapid growth in understanding of multiple meanings between the ages of 9 and 12 years (Asche & Nerlove, 1960; Schecter & Broughton, 1991), with comprehension development of less common multiple meanings continuing through adolescence (e.g. Nippold, Cuyler, & Braunbeck-Price, 1988). Nippold et al. (1988) examined understanding of double meaning words within advertisements. Double meaning words have both a physical and psychological meaning (e.g. sweet, cold). Forty participants aged 9, 12, 15, and 18 years were tested. Each participant was presented with 14 written advertisements that contained double meaning words and four advertisements with a single meaning. A steady growth in understanding was exhibited with increasing age. Significant differences were found among the four age groups except between the 12- and 15- year olds and the 15- and 18- year olds. It was concluded that development did continue after 12 years of age but at a slower rate than between the ages of 9 and 12 years (Nippold et al., 1988).

Knowledge of adverbs improves with age (Nippold, 1998) and contributes to vocabulary expansion through adolescence. Hoffner, Cantor, and Badzinski (1990) examined understanding of the modal adverbs *possibly, probably,* and *definitely*. Children aged, 5, 7, 9, and 10 years (n = 78) listened to stories that contained the adverbs and then predicted what happened. Performance in comprehension improved with age, with the adverb *definitely* being understood the earliest. By 10 years of age, 86% of the children understood the difference between *possibly* versus *definitely* and *probably* versus *definitely* but only 55% understood the difference between *possibly* and *probably*. The understanding of 10-year-old children was just above chance for the latter distinction. Similar results were found for adverbs of magnitude (e.g. *slight* versus *considerabl*e). In a comprehensive literature review, Nippold (1998) reported that understanding of adverbs of magnitude was dependent on the degree of magnitude, and that with age, participants were able to make smaller discriminations. Even college-age students had difficulty making distinctions between words terms such as *quite* large versus *decidedly* large.

Like adverbs of magnitude and likelihood, factive verbs (e.g. know) and non-factive verbs (e.g. think) relate to the certainty of truth. Scoville and Gordon (1980) investigated the development of factive verb comprehension. They studied 48 children aged 6, 8, 12, and 14 years of age along with 28 adults. All participants were presented with sentences such as "*He knows the ball is red*," or, "*He thinks the ball is red*" and answered a question such as

"*Is the ball red*?" Transition to adult understanding was gradual with no definite stage of development resulting in a dramatic shift in understanding.

It is not surprising that vocabulary develops through the lifespan. As individuals are introduced to new social and academic experiences, new words are acquired. Nonetheless, improved understanding of multiple meanings and every-day words such as factive and non-factive verbs and adverbs may not always be considered as developmentally advanced terms. There are a number of published tests that examine vocabulary, however it is important when assessing adolescents to include assessment of later-developing semantic forms such as multiple meanings.

1.1.3 Syntactic and Lexical Ambiguity

Comprehension of ambiguous sentences is related to improved understanding of syntax and multiple meanings. Understanding ambiguous sentences involves hearing or reading a sentence that has more than one meaning, and arriving at the final meaning by drawing on context, world knowledge, or the remainder of the sentence. Sentences may be ambiguous due to lexical or syntactic ambiguity. Lexical ambiguity in a sentence occurs when a single word may have more than one meaning (e.g. *"The man wiped the **glasses**"*). Syntactic ambiguity occurs when either the surface-structure of a sentence or the deep-structure of a sentence is ambiguous (e.g. "*The duck was ready to eat.*"). MacKay and Bever (1967) examined the time required for adults to interpret lexical and syntactic ambiguities in sentences and found that lexical ambiguities were identified more quickly than syntactic ambiguities. In addition, adults identified surface-structure ambiguities faster than deep-structure ambiguities. Hence it was concluded that perception time reflected the difficulty of the ambiguity with lexical ambiguities being easier to comprehend than surface-structure ambiguities, which, in turn, are easier to understand than deep-structure ambiguities.

Schultz & Pilon (1973) presented children aged 6, 9, 12, and 15 years of age with 24 ambiguous sentences. In addition to a picture-pointing task, participants were required to explain the meaning of each sentence. Unlike Wiig et al. (1978) they found that lexical and phonological ambiguities were mastered by age 15 whereas surface and deep structure ambiguities were not understood before age 12 and still not mastered by 15-year-old students. There was no difference between sentences with deep and surface structure ambiguities. The results demonstrate that different types of ambiguities and different task demands may affect results.

Wiig, Gilbert, & Christensen (1978) tested children age 5, 7, 10, 12, and 18 years on tasks requiring comprehension of ambiguous sentences. Participants were presented with lexical, surface-structure and deep-structure ambiguities. Understanding was measured by speed and accuracy of response to a picture-pointing task. It was found that the number of correct responses increased with age. There were no differences among ambiguity types, however, this may have been because some of the lexical ambiguities involved idiomatic expressions and therefore may have been more difficult than typical lexically ambiguous sentences (Nippold, 1998).

Nippold et al. (1988) examined understanding of lexical ambiguities in a naturalistic context. Participants aged 9 through 18 years explained ambiguous advertisements that appeared in magazines, newspapers, and brochures. Each advertisement contained a different type of lexical ambiguity: homonyms (e.g. *grate* versus *great*), double meaning words (e.g. *move* physically versus *move* emotionally), and idiomatic expressions that could have both a literal and figurative interpretation (e.g. *upper crust*). The purpose was not to compare different types of ambiguities, but rather to determine whether development of understanding continues through adolescence. All participants had improved understanding with increasing age, with the greatest development occurring between 9 and 12 years of age.

Development did continue through to 18 years and Nippold et al. noted that only 30% of the 18-year-old participants achieved mastery.

Developmental differences in understanding ambiguous sentences may be influenced by the development of multiple-meaning words and syntax. Differences may also reflect changes in working memory through adolescence. Just and King (1991) hypothesized that when an ambiguous sentence is presented, all possible meanings are held in working memory until enough information is provided to resolve the ambiguity. The *Test of Language Competence-Expanded (TLC-E)* (Wiig & Secord, 1989) is one of the few standardised tests that measures comprehension of ambiguous sentences. In this task, participants are required to explain the ambiguity. Thus, when using the test for adolescents with TBI, it is difficult to determine whether poor performance is due to impaired comprehension or whether it is a reflection of poor oral formulation. Although assessment of syntactic and lexical ambiguity comprehension is necessary, there are no standardised tests available for that purpose.

1.1.4 Figurative Language

Figurative language refers to expressions that represent a concept beyond the literal interpretation of the words. Idioms and proverbs are two types of figurative expression that have been shown to develop in adolescence.

Children as young as 5 years were able to understand some idioms in an experiment conducted by Brinton, Fujiki, & Mackey (1985). Twenty children aged 5, 7, 9, and 11 were presented with six idioms that were selected from television cartoons. Children listened to a short story followed by the idiom and pointed to one of four pictures that best depicted the idiom. Accuracy scores ranged from 22% for the five-year-old children to 62% for the 11-year-old children.

Since idiom comprehension was not mastered by age 11 (Brinton et al., 1985), growth in understanding must occur beyond that time. Development of idiom comprehension in adolescence was examined in participants aged 14, 15, 16, and 17 years of age (Nippold & Martin, 1989). A large sample population (*n* = 475) was administered a modified version of the idioms subtest from the *Fullerton Language Test for Adolescents* (Thorum, 1980). Students were presented with 20 idioms and were required to write an explanation of the expression. Half of the idioms were presented in isolation, and half were presented within a short story. Accuracy scores for the idiom explanation task ranged from 54% for the fourteen-year olds to 67% for idioms in isolation, and from 65% to 72% for idioms in context. The 17-year-old students did better than the younger participants, but even they had not reached mastery.

Proverbs are figurative expressions that teach a lesson or contain a moral. Although young primary school children can understand some proverbs (Honeck, Sowry, & Voegtle, 1978), comprehension of these expressions continues to improve during late childhood, adolescence, and well into adulthood (e.g., Nippold, Allen, & Kirsch, 2000; Nippold & Haq, 1996; Nippold, Hegel, Uhden, & Bustamante, 1998; Nippold, Martin, & Erskine, 1988; Nippold, Uhden & Schwarz, 1997). In order to evaluate proverb comprehension through the lifespan, Nippold et al. (1997) presented 24 low-familiarity proverbs to 353 individuals. The age range of the participants was from 13 years of age to 79 years of age. There were two groups of adolescents: 13-14 years (*n* = 52), 16-17 years (*n* = 43) and six groups of adults: 20-29 years (*n* = 41), 30-39 years (*n* = 41), 40-49 years (*n* = 49), 50-59 years (*n* = 43), 60-69 years (*n* = 40) and 70-79 years (*n* = 44). The proverbs were presented in a short story context and participants were asked to write down what they thought the proverb meant. There was a significant group effect for age with the 13- year olds scoring significantly lower than the older age groups. There was also a significant difference in the performance of 16- year olds and the adult groups below the age of 60, with the 16-year olds scoring below the adults. There was no significant difference among the 20-, 30-, 40- or 50-year-olds and a decline in performance for the two senior adult groups. The continued growth of proverb understanding in adolescence supports the need to assess figurative language in adolescents. It also reinforces the need for assessment tools that are sensitive to the changes in adolescence.

1.1.5 Summary of Development

Research has provided evidence for continued language development through adolescence in the areas of syntax, vocabulary, and figurative language. Descriptions of language development are highly dependent on the tasks being used to measure the behaviour. Stimuli and response task variables can influence understanding of how language develops in older youth. Further research into adolescent language development is needed in order to have a comprehensive understanding of adolescents' linguistic behaviour, and to determine the types of tools that are sensitive to changes in adolescence. Understanding impairment in adolescents with brain injury is reliant on understanding typical language development and the sensitivity of the tools we use to measure performance.

1.2 Language of Adolescents with TBI

There is a paucity of research related to the linguistic characteristics of adolescents with TBI. The expected outcomes of TBI when a child reaches adolescence often have to be inferred from the literature examining children and adults. Previous research investigating linguistic outcomes in children and adolescents with TBI is limited by several factors. First, the assessment tools used to evaluate language outcomes were either not comprehensive or were not suitable for the population. Arsanow, Satz, Light et al. (1995) administered a neuropsychological test battery to children and adolescents with mild head injury. Language outcomes were assessed using only the *Peabody Picture Vocabulary Test (PPVT)* (Dunn & Dunn, 1981). It was concluded that the head-injured group did not differ linguistically from the control group. However, the *PPVT* examined only receptive vocabulary. Expressive language, and understanding of language beyond a single-word level was not assessed. Other studies (e.g. Ewing-Cobbs, Levin, Eisenberg, & Fletcher, 1987) used assessment tools that were not designed for a pediatric population. Second, the studies that used appropriate tests (e.g. Hinchliffe, Murdoch, & Chenery, 1998; Jordan & Murdoch, 1993) grouped adolescents with children or adults and did not consider the unique developmental stage of adolescence.

Despite limitations, the findings of the studies contributed to the understanding of language in young people following TBI and have offered direction for further research. Two hypotheses that have evolved from the literature are the "developmental hypothesis" (Dennis, 1989: Ewing-Cobbs et al., 1987) and the "high-level language skills" hypothesis (Hinchliffe et al., 1998; Jordan & Murdoch, 1994).

The " developmental hypothesis" proposes that language skills that are developing, or yet to develop, are likely to be affected following a TBI (Dennis, 1989; Ewing-Cobbs et al., 1987). Ewing-Cobbs et al. (1987) suggested that those language skills that are rapidly developing are most likely to be impaired following a brain injury. These researchers assessed 23 children (aged 5 to 10 years) and 33 adolescents (aged 11 to 15 years) with recent head injury (median injury-test interval was one-month post-injury) using the Neuorsensory Center Comprehensive Examination for Aphasia (NCCEA) (Spreen & Benton, 1969). The children and adolescents with head injury were separated according to age and severity of injury. Composite scores for expressive and receptive language were obtained. The participants with mild-moderate head injury and the participants with severe head injury had expressive deficits whereas comprehension was affected for the participants with severe head-injury only. Ewing-Cobbs et al. (1987) concluded that expressive skills were developing more rapidly than comprehension skills and therefore were sensitive to brain injury. The notion that rapidly developing skills were more likely to be affected following TBI was supported when the different age groups were compared. Adolescents differed from children only in that their performance on a "writing to dictation" task was superior. The discrepancy in performance was explained on the basis that writing to dictation develops between the ages of 6 and 8 years and children who had their injury prior to that time would demonstrate impairment.

In a related study supporting the developmental hypothesis, academic achievement following TBI was examined (Ewing-Cobbs, Fletcher, Levin, Iovino & Miner, 1991). Thirty-eight children, aged 5 to 10 years, and 23 adolescents, aged 11-15 years were assessed at baseline (within 21 days of injury), 6 months, 12 months and 24 months following their injury. Academic achievement was assessed using the *Wide Range Achievement Test* (WRAT) (Jastak & Jastak, 1978) and the *Peabody Individual Achievement Test* (PIAT) (Dunn & Markwardt, 1979). The children and adolescents were grouped according to the severity of injury. Academic achievement was related to severity of injury with the severely- head injured participants (n = 28) scoring lower than participants with mild-moderate TBI (n = 33). Adolescents and children differed on arithmetic and reading comprehension scores. Arithmetic and reading comprehension scores at baseline were more impaired for the adolescents than children. Arithmetic scores were significantly lower than word recognition, spelling, and reading comprehension scores. Word recognition for both groups was significantly higher than reading comprehension and spelling. It was hypothesized that reading recognition may have been intact because all the children were 5 years or older at the time of injury and therefore decoding skills were more firmly established (Ewing-Cobbs et al., 1991). The researchers argued that the findings offered some support for the rapid development hypothesis (Ewing-Cobbs et al., 1987) in that reading comprehension develops later than decoding therefore was more likely to be impaired in the age groups tested. However, the proposal is not consistent with theories of reading and word recognition that emphasise that word recognition accounts for much of the variance in reading comprehension at all levels (Stanovich, 1985).

Two primary problems were noted in Ewing et al.'s (1987) study that challenge the developmental hypothesis. First, the effect of TBI on adolescents who had their injury prior to adolescence was not assessed. Developing linguistic skills were proposed to be more impaired than firmly established skills (Dennis, 1989; Ewing-Cobbs et al, 1987, 1991) therefore impairment may not be evident until the time when mastery of the developing skills would be expected (Dennis, 1989). Testing of individuals whose injury occurred prior to the language growth that takes place in adolescence is likely to be more sensitive. The second problem with Ewing et al's research was that the tests used were not developed for a pediatric or adolescent population (Murdoch & Theodoros, 2001).

Developmental tests, suited to a pediatric population, were used in a series of child and adolescent studies conducted by Jordan and colleagues (Jordan, Cannon & Murdoch, 1992; Jordan, Cremona-Meteyard & King, 1996; Jordan & Murdoch, 1990, 1993, 1994; Jordan, Ozanne, & Murdoch, 1988). In addition, the studies examined the affects of TBI on language development over time. In the first of a series of studies, Jordan et al. (1988) used developmentally appropriate tests to assess 20 children and adolescents with head injury, aged between 8 and 16 years, who were at least 12 months post-injury. The participants were divided into those with severe head injury (*n* = 10) and those with mild head injury (*n* = 10). Tests administered included *the Test of Language Development-Primary (TOLD-P)* (Newcomer & Hammill, 1982) for the younger participants and the *Test of Language*

Development-Intermediate (TOLD-I) and *Test of Adolescent Language-2 (TOAL-2)* (Hammill, Brown, Larsen, & Wiederholt, 1987) for the older participants. Two tests designed for adults with aphasia, the *NCCEA* (Spreen & Benton, 1969) and the *Boston Naming Test (BNT)* (Kaplan, Goodglass, & Weintraub, 1983) were administered. As a group, the participants with head injury scored significantly below a normal control group on the *TOLD-P* and *TOLD-I.* Post-hoc analysis revealed a significant difference in overall language quotient scores for severely head-injured participants and normal matched controls. There was no difference between the mild head-injured group and the control group nor the mild head-injured group and the severely-head injured group. The language quotient for both the severe and mild-head injured groups was within normal limits compared to the standardisation sample. There were no significant differences among the groups on the *NCEAA* and significance was achieved only between the severely head-injured participants and the normal control group. The primary area of deficit noted was word retrieval as measured by the BNT however, again only the severely head-injured children were significantly impaired relative to the control group. The tests were sensitive to differences between a head-injured group and a control group, even though performance of all groups was within normal limits.

In order to examine the effects of the TBI on language over time, the participants in Jordan et al.'s (1988) study were reassessed 12 months later to determine if changes took place over time (Jordan & Murdoch, 1990). Although performance improved at the time of the second assessment, the head-injured participants, as a group, continued to have language quotients that were significantly lower than the control group. Verbal fluency was the only measure to decrease over the 12-month period. The authors' suggested this may have reflected an impairment in newly developing skills supporting Ewing-Cobbs et al.'s (1987) hypothesis. The types of difficulties the head-injured groups were demonstrating on the TOLD tests were not specified.

A prospective study of the outcomes of head injury at the time of injury and at 6-, 12-, and 18-months post-trauma for children and adolescents was conducted using developmentally appropriate language tests (Jordan & Murdoch, 1993). Children, aged 5 to 13 (n = 11) were assessed on a variety of linguistic measures. Six of the children had severe head injury and five had mild head injury. Tests included the *TOLD* series, the *NCCEA, TOAL-2* (Hammill et al, 1987) and two naming subtests of the *Clinical Evaluation of Language Fundamentals (CELF)* (Semel-Mintz & Wiig, 1982). Overall results revealed that performance on the language tests improved with time with the exception of word retrieval difficulties, which persisted for most. Examination of the individual data revealed that three participants continued to perform below average on an overall language quotient. Contrary to expectation, one had average performance at the time of injury and at 6 and 12 months post-impairment but showed significant impairment at 18 months. It was proposed that the relatively poor performance at 18 months was a reflection of the more difficult language test (*TOAL-2*) that was administered at 18 months in order to accommodate the participants' age. Despite the *TOAL-2* being suited to the participants' age, the participant had not continued to develop according to expectation. Jordan & Murdoch (1993) noted that there was an increase in the written language requirements of the test. Because the same tests could not be used across the age range of the participant, it was difficult to determine whether the poor outcome on the later language test was related to the head injury. The decrease in performance with increasing age could offer some support to Ewing-Cobbs et al.'s (1987) theory that developing skills are affected following TBI.

The studies (Jordan & Murdoch, 1990, 1993) offered some support for the hypothesis that language skills that are still developing are affected by head injury in childhood, however with the exception of word-retrieval, deficits in later developing language skills were not evident. It is possible that the amount of time between injury and testing was not sufficient to reveal the affects of head-injury on the subtle changes in language development that occur in adolescence. Jordan and colleagues (Jordan, Cannon, & Murdoch, 1992; Jordan & Murdoch, 1994) addressed that issue when they examined the effects of childhood impairment on adults. Jordan & Murdoch (1994) examined eight severely head-injured adults who had acquired their injury in childhood. The age of injury ranged from 7; 1 years to 16; 6 years. The participants received a battery of tests that included the *TOAL-2*, the *BNT*, the *Test of Language Competence-Expanded (TLC-E)* (Wiig & Secord, 1989), the *Token Test* (Spreen & Benton, 1969), the *Peabody Picture Vocabulary Test-Revised (PPVT-R)* (Dunn & Dunn, 1981), and the *FAS Verbal Fluency* test (Spreen & Benton, 1969). The head-injured group performed below average when compared to a control group on all the language tests. Besides allowing time between injury and testing, another strength was the inclusion of the *TLC-E* which Hinchliffe et al. (1998) identified as targeting high level language processes such as inference and figurative language comprehension.

A second long-term outcome study looked at children who had their injuries prior to adolescence (Jordan et al., 1992). The participants were mildly head injured and age range at time of injury was from 6 years to 12 years. All participants were assessed at least ten years post-injury. Assessments administered included the *TOAL-2*, the *NCCEA*, and the *BNT*. No significant differences were found between the head-injured group and an age-matched control group. This study did not support the hypothesis that developing skills were affected by head-injury in the long term. It was possible that the failure to find differences among the groups was because the participants were mildly head-injured (Jordan et al., 1992). Another possibility is that the tests used were not sensitive to high level language skills. Although the authors stated that the *NCCEA* targeted some high level language skills, it was not clear what skills those were. Perhaps if a test such as the *TLC-E* had been included, areas of impairment may have been identified

The "high-level language" hypothesis was put forward by Hinchliffe et al. (1998) They observed that many studies had used aphasia assessments (e.g. Levin et al., 1987) or neuropsychological batteries (e.g. Hartley & Jensen, 1991) for assessing language impairment in individuals with TBI. The problem with using aphasia and neuropsychological assessments is that a limited range of language behaviour is assessed. Assessments that looked at "higher order" language skills such as inference, understanding ambiguous sentences, and understanding figurative language would be more sensitive to linguistic impairment following TBI (Hinchliffe et al., 1998). In order to test their hypothesis, a battery of standardised language tests was administered to 23 individuals with brain injuries ranging in age from 16 to 50 years (Hinchliffe et al., 1998). All participants had Glasgow Coma Scales of 8 or less. Three groups of language tests were administered. The first group included traditional aphasia tests which assessed primary language processes such as sentence comprehension, confrontation naming and sentence repetition (Hinchliffe et al., 1998). The second group of tests targeted higher-level language processes. These included tasks that involved strategic language processes that targeted metalinguisic competence, integrative language skills and lexical-semantic skills. The third group consisted of subtests of the Right Hemisphere Language Battery. In addition, a neuropsychological assessment was carried out that measured constructs of memory, attention, intelligence and visuospatial abilities. Results supported the hypothesis that language tests that examined "higher-level" language skills did identify people with TBI from a group of participants without TBI. Individuals with TBI achieved significantly lower means for all subtests in Battery 2 whereas in Battery 1 differences were noted between the groups on only a few subtests (naming, auditory comprehension of complex sentences and reading comprehension). It was concluded that developmental language tests such as the *Test of Language Competence-Expanded* (Wiig & Secord, 1989), *The Word Test-Revised* (Huising, Barrett, Zachman et al., 1990) and the *Test of Word Knowledge* (Wiig & Secord, 1992) may be useful in identifying language outcomes following TBI in adults (Hinchliffe et al., 1998).

High-level language processes such as making inferences and understanding ambiguous sentences were assessed in 11 children with severe head injury (Jordan, Cremona-Meteyard, & King, 1996). The *TLC-E* was the only test administered. The subtests included: understanding ambiguous sentences, making inferences, oral expression, and figurative language comprehension. The participants were children and adolescents who had sustained their injuries between the ages of 5 and 13 years. The time lapsed since the participants' head injury ranged from one to eight years. The group of participants with head injury had significantly impaired performance compared to the control group on an overall language quotient. When specific subtests were compared, the groups differed significantly on all tasks with the exception of Making Inferences subtest. This supports Hinhliffe et al.'s hypothesis that high-level language tests are sensitive to impairments following TBI. The participants in Jordan et al.'s (1996) study were all severely head-injured, therefore information regarding the effects of high-level language skills on adolescents with moderate or mild injuries is not known.

The series of studies conducted by Jordan and colleagues demonstrated that language deficits are likely to occur following childhood brain injury. Some support was given to the hypothesis that language that is continuing to develop is affected by head injury (Jordan & Murdoch, 1990, 1994; Jordan et al. 1988). In addition, there was support for the hypothesis that high-level language skills are affected following brain injury. The results, however, are somewhat difficult to interpret considering that the studies differed in terms of participants' ages at time of injury and time of testing, severity of head-injury, and test complexity. Further, in some studies specific subtests scores were reported whereas in other studies only overall language quotients were examined. Although the studies provided useful information, the picture related to outcomes in adolescents following head-injury in childhood is still unclear.

One study that looked specifically at adolescents following head-injury (Turkstra, 1999) used the *Clinical Evaluation of Language Fundamentals-3 (CELF-3)* (Semel, Wiig, & Secord, 1995). The *CELF-3* was chosen as it was well standardised for adolescents. The Participants were 11 adolescents aged 13; 3 to 21; 7 who had sustained head injuries within three years of testing. Of the participants, six participants were diagnosed as having verbal information processing impairments, but none of these participants had been referred to speech and language therapy services. Five participants had communication impairments that had been documented by a speech-language therapist. The results from the *CELF-3* revealed that five participants had scores that fell more than 1 standard deviation below the mean. Participants who had been identified as having verbal memory impairment on the neuropsychological testing were not identified as being language-impaired on the *CELF-3* (Turkstra, 1999). There were no differences between receptive and expressive scores for any of the participants. All participants, regardless of test scores, had difficulty with listening, reading, writing, and speaking in school and required academic assistance. One problem with this study is that the author used a very broad definition of adolescence. Eight of the eleven participants were aged 16 and over at the time of injury and 18 and over at the time of testing. An individual of that age could be considered an adult. In addition, the participants who had their head injury after 16 years may not have had as much language growth as children who had their injuries earlier. Examination of the individual scores however, revealed that some of the older students were the ones who were identified on the language test. Failure to find linguistic deficits in the presence of academic deficits may be because the *CELF-3* did not target the high-level language skills described by Hinchliffe et al. (1998). It also suggested that available language tests are not sensitive to language deficits that may contribute to academic difficulties. The results were consistent with Ewing-Cobbs et al. (1991) who demonstrated that children have persisting academic deficits following TBI.

Profiles of language impairment in individuals with TBI are dependent on many aspects of a study. The primary factors that have been identified in the literature review of outcomes for adolescents following TBI have related to the types of assessments used to evaluate the participants, whether the injury was sustained in childhood or adolescence, and academic performance. The types of task used relates to the hypothesis that "high-level language" tests are more sensitive to the effects of TBI on language. The age of the individual's injury and the amount of time that has passed since the injury relates to the "rapidly developing hypothesis". That is, sufficient time between injury and testing would need to have lapsed in order for linguistic development to occur. The severity of injury is important to consider as well, as the studies are suggesting that mildly head-injured participants are less likely to demonstrate problems, yet at least one of the studies that examined mild-head injury did not include high-level language tests (e.g. Jordan et al., 1992). Academic performance, although discussed in only two of the aforementioned studies is worthy of consideration particularly considering that academic performance may be affected even in the absence of significantly lowered results. It suggests that academic performance should be considered in future studies that examine profiles of children and adolescents with TBI.

1.2.1 Language Comprehension and TBI

The studies described have investigated overall language performance in children and adolescents. Except for the study conducted by Ewing-Cobbs et al. (1987) the research did not differentiate between comprehension and expression. Current literature in traumatic brain injury has focused primarily on expressive language disorders in children with TBI (e.g. Chapman, 1997; Dennis & Barnes, 2000; Snow, Douglas & Ponsford, 1995). Studies of expressive language (e.g. Campbell & Dolloghan, 1990) including discourse studies (e.g. Chapman, 1997) have greatly improved understanding of communication impairment following TBI, however little attention has been given to auditory comprehension profiles of children and adolescents with TBI. Examination of auditory comprehension profile may provide support for current hypotheses or provide direction for new hypotheses to be explored.

Investigations using high-level language tests have indirectly targeted auditory comprehension as part of an overall language profile and have identified deficits in both children and adults with TBI (e.g. Hinchliffe et al., 1998; Jordan et al., 1996). Understanding inference, figurative language and long, complex utterances have been shown to be impaired. Specific aspects of comprehension in individuals with TBI have also been explored (Dennis & Barnes, 1990; Holland & Turkstra, 1998; Nicholas & Brookshire, 1995; Towne & Entwhistle, 1993). Studies of discourse comprehension comparing adults with TBI to non-brain injured participants have demonstrated impairments (Kewman, Yanus, & Kirsch, 1988; Brookshire & Nicholas, 1995). Kewman et al. (1988) had participants listen to passages with and without distraction. Participants performed significantly poorer than a control group in both conditions. Nicholas and Brookshire (1995) compared four groups of participants on a discourse comprehension test. Three of the groups had brain damage (aphasia, right hemisphere damage, and TBI) and the fourth was a non-brain damaged control group. There were no significant differences among the brain-injured groups however participants with brain injury had significantly impaired performance compared to the normal control group. Participants with brain damage were more accurate answering questions that involved stating main ideas than questions about detail. Performance for the brain-injured group was also better when information was stated directly rather than inferred.

Studies of comprehension of figurative language in children and adolescents with TBI (e.g. Jordan et al., 1996; Towne & Entwhistle, 1993) have produced inconsistent results. Using the *TLC-E*, Towne and Entwhistle (1993) assessed figurative language comprehension in adolescents with TBI and a matched control group. The adolescents with TBI did not perform significantly different to the control group on the Figurative Language subtest of the *TLC-E*. Towne and Entwhistle's (1993) results conflict with Jordan et al. (1996) who found that 11 head-injured children aged 5 to 13 had significant impairment on the Figurative Language subtest of the TLC-E compared to a group of controls. The results were also inconsistent with Hinchliffe et al. (1998) who also found figurative language to be impaired in adults with head injury. Further research is needed in the area of figurative language comprehension and TBI to explore the conflicting results and determine whether figurative language is impaired following TBI.

Assessment of inference comprehension has also produced mixed results in the literature. Inferencing is a strategic language process that requires the integration of known information with the context so that information can be implied. Studies of adults have shown inference comprehension to be impaired (e.g. Hinchliffe et al., 1998; Brookshire & Nicholas, 1995). Inference has also shown to be impaired in children with TBI (e.g. Dennis & Barnes, 2000) however Jordan et al. (1996) found that it was the one subtest of the *TLC-E* that children with TBI were not impaired with. Factors that influence the comprehension of inferences in children and adolescents with TBI need to be further examined.

Listening is the most frequently used communication skill (Hartley, 1995). For children in primary school, approximately 60% of time is spent listening in the classroom (Lazar et al., 1989). Time spent listening increases in secondary school. Considering the presence of academic deficits, even in the absence of significantly reduced test scores, the existence of comprehension deficits must be considered. As receptive language continues to develop through adolescence it is likely that those skills will be impaired in individuals who have had their injury in childhood. Furthermore, the presence of auditory comprehension deficits in adults and children using tests of high-level language supports the need for further research.

1.3 Working Memory and Language Comprehension Deficits in TBI

Two hypotheses have been advanced to explain the language deficits in children and adolescents with TBI: the "rapidly developing language hypothesis" and the "high-level language hypothesis". Both hypotheses have merit and have found support in the literature. There are limitations to both hypotheses as well. The rapid developmental hypothesis could only really be considered if normal language development data was available. Furthermore, Ewing-Cobbs et al.'s (1987) study did not identify language skills that were "rapidly" developing as opposed to gradually a priori. Finally, there was no explanation as to why rapidly developing language should be more affected by head injury than gradually developing language. The authors may have been suggesting all developing skills were prone to impairment but this was not made clear. The "high-level language skills" hypothesis also warrants attention as it has been supported in studies with both adults and children with TBI (Hinchliffe et al., 1998; Jordan et al., 1996). The shortfall of this hypothesis is two-fold. First, the term "high-level language skills" has not been well defined. High-level language skills are not synonymous with later-developing language as even young children can make certain inferences and understand some figurative language. Hinchliffe et al. (1998) supposed that high-level language skills involved metalinguistic and metacognitive competence. However, they did not specify what metalinguistic or metacognitive knowledge was required for various tasks. In addition, not all the tests they proposed for assessing high-level language required metalinguistic competence. For example, familiar figurative language may be understood as an entire semantic unit without analyzing its components (Nippold, 1998). The second problem is that results using tests that assess high-level language have been inconsistent. Finally, both explanations of the language outcomes following TBI have resulted from ex post facto research. Ex post facto research is highly useful in directing future research but it cannot truly explain an event on the basis of the results (Hegde, 1987). Explanation of an event requires an experimental approach involving manipulation of an independent variable. Both the "rapid developing hypothesis" and the "high-level language" hypothesis are difficult to test experimentally. An alternative hypothesis for explaining linguistic deficits in children and adolescents with TBI is a working memory capacity hypothesis. The hypothesis is particularly compelling when considering auditory comprehension deficits in TBI.

Working memory has been related to listening comprehension abilities in individuals with and without brain damage (e.g. Just & Carpenter, 1992; Just & King, 1991). Working memory is defined as a temporary storage place where processing of information can occur (Baddeley, 1986; Just & Carpenter, 1992). If working memory is accepted as an area of storage and processing of information, then language comprehension is likely to involve working memory (Carpenter, Miyake & Just, 1994). Both listening and reading comprehension involve the storage and processing of information over time. For instance, as a person hears something being said, the person must store the information while extracting meaning from it (processing). Carpenter et al. (1994) highlight the importance of the storage component of working memory in that "The linearity of language necessitates temporarily storing the intermediate and final products of a reader's or listeners' computations as she/he constructs and integrates ideas from the stream of successive words in a text or spoken discourse" (p.1075). Carpenter et al. (1994) also highlight the importance of the processing component of working memory as they describe working memory as "...the pool of resources that perform the symbolic computations and thereby generate the intermediate and final products."(p.1075).

There are a number of reasons to consider working memory as a model for understanding the language comprehension deficits in individuals with TBI. First, a number of studies have shown the presence of working memory deficits in individuals with TBI (e.g. Hinchliffe et al., 1998; Hartley, 1995, 1998; Ewing-Cobbs et al., 1989). Furthermore, auditory comprehension deficits in adults with TBI are strongly correlated with memory deficits following TBI (Hinchliffe et al., 1998). It was not specified whether it was working memory that was associated with the auditory comprehension deficits but the findings provide impetus for further study. Hinchliffe, Murdoch, and Theodoros (2001) noted that the memory factor was more highly associated with basic auditory comprehension than high-level auditory comprehension such as understanding figurative language, inference and comprehending ambiguous sentences. They concluded that basic auditory comprehension relied more heavily on working memory than the complex/integrative comprehension tasks. Their conclusion is contrary to studies of normal language comprehension that demonstrate that working memory is involved in integrative comprehension such as understanding ambiguous sentences (MacDonald & Just, 1992). The contribution of working memory to the language comprehension, including comprehension of syntax, vocabulary, figurative language, inference and discourse requires further investigation.

Working memory as a model for explaining the comprehension deficits following TBI is compelling philosophically as well. The current, and most accepted paradigm for explaining communication deficits in TBI is that there is a primary cognitive problem i.e. a problem with attention, memory, or executive functioning and that communication difficulties are a result of that impairment. That paradigm views language as secondary to cognition. There are a number of problems with that model. First, the paradigm suggests that language and cognition are separated rather than language being viewed as a cognitive function. Secondly, the model is hierarchical in that it assumes higher order or lower order functions and ignores parallel processing. It has been argued that linguistic deficits following TBI are more likely to be an interaction between linguistic proficiency and cognitive function (Hinchliffe et al., 1998; 2001). The argument for an interaction between linguistic and non-linguistic cognitive function is supported by the language development literature (Bloom & Lahey, 1978;Vygotsky, 1962) as well as research demonstrating the strong correlation between linguistic and non-linguistic tasks (Hinchliffe et al., 1998). Correlations between neuropsychological tests and language tests are further supported by neuroanatomical development. Anderson (1998), in her review of executive functioning, noted that development of the frontal lobe is hierarchical and that reticular tracts and tracts that connect specific and associative cortical areas are still developing at school age and show development into adulthood. Improvement on behavioural tests of executive functioning may in fact be a reflection of development in other areas. Development in areas such as language, memory, and speed of processing may all be contributing to better performance in executive functioning. Finally, the model doesn't explain aspects of performance such as variability in performance across different language tasks and across situations, nor does it explain response to stimulability.

On the surface working memory appears to be a model of nonverbal cognition, however studies of working memory and language comprehension have demonstrated the interaction between language and non-linguistic cognition (e.g. Just & Carpenter, 1992; King & Just, 1991) There are slight variations on the way working memory is conceptualized, however the basic premise of working memory models is that they are limited capacity systems with fixed resources available for processing language. If a person has inefficient language processing, greater resources may be needed to perform the task. Likewise if working memory capacity is limited, language processes that are simple will be intact whereas more complex linguistic processes will be impaired.

1.3.1 Baddeley's Model of Working Memory

Working memory, as an area of storage and processing, was first proposed by Baddeley and Hitch (1974). The definition of working memory has evolved and is currently defined as "...functional components of cognition that allow humans to comprehend and mentally represent their immediate environment, to retain information about their immediate past experience, to support the acquisition of new knowledge, to solve problems, and to formulate, relate, and act on current goals" (Baddeley & Logie, (1999, p. 29). The storage and processing of information allows working memory to have a vast role in complex cognition, including language comprehension. Baddeley's (1986) model of working memory is a multicomponent system made up of the central executive, phonological loop, and visuospatial sketchpad.

Phonological Loop

The phonological loop is one of two storage systems in working memory. It is specific to the storing of verbally coded information (Baddeley, 1986). The phonological loop can be separated into two components: a passive storage system, and an active rehearsal system. The passive storage system represents information in a phonological code which decays over time. The active rehearsal system involves a subvocal rehearsal process that refreshes the decaying information so that it can be maintained over a longer period of time. In addition, the subvocal rehearsal process takes non-auditory information such as printed words and turns them into phonological information that can be stored. The phonological loop, like other components of working memory, depends on activation (Baddeley & Logie, 1999). Activation is limited however, in both amount and duration. Only a set amount of information can be retained in the phonological loop and for a set amount of time. Evidence of the temporal and capacity constraints of the phonological loop has been collected in studies examining articulatory suppression (Baddeley, 1986; Gathercole & Baddeley, 1993), word length (Baddeley, Thompson, & Buchanan, 1975; Ellis & Henneley, 1980), phonological similarity (Conrad & Hull, 1964; as cited in Baddeley, 1986), and neuropsychological evidence (Baddeley & Logie, 1999; Vallar & Baddeley, 1984).

Visuospatial sketch pad

The visuospatial sketch pad is the slave system that specialises in the storage and maintenance of visual and spatial material. It also stores and processes verbal information that is transformed to visual information (Gathercole & Baddeley, 1999). The visuospatial sketch pad is not thought to play a major role in auditory comprehension.

Central Executive

The central executive is involved in: the control and coordination of the two storage systems, ability to activate and retrieve information from long-term memory and the capacity to focus and switch attention (Baddeley & Logie, 1999; Baddeley, 1986).

The central executive has been compared to Shallice's (1982, 1988) Supevisory Attentional System (SAS). The SAS controls processing in two ways: automatic activities are guided by scripts or schemas so that actions are automatic whereas controlled activities require extra attention. An example of an automated routine is driving (Gathercole & Baddeley, 1993) whereby a need to slow down will automatically trigger the individual to brake or change gears. When the action is new or urgent or requires extra attention, the SAS intervenes and controls the action so that automatic responses are overridden (Gathercole and Baddeley, 1993). The controlled action of SAS is demanding of cognitive resources whereas the automatic actions require very few resources. Baddeley and colleagues point out that the central executive is not synonymous with the SAS but the SAS may provide some explanation as to how it works (Baddeley & Logie, 1999; Gathercole & Baddeley, 1993).

Baddeley's Model of Working Memory and Comprehension

If the phonological loop is involved in language comprehension, it is likely to be used when the listener encounters long or syntactically complex utterances (Gathercole & Baddeley, 1993). It is a basic tenet of language comprehension that understanding of sentences with simple syntax and semantic structures occur automatically while the listener is hearing the sentence. However, sentences with complex syntax or those with difficult semantic elements may require storage for processing of the utterance to take place (Gathercole & Baddeley, 1993). Sentences that use complex syntax such as passives, "*John was hit by James*", or sentences with center-embedded clauses "*The boy **that was carried by the girl** had red hat*" (Gathercole & Baddeley, 1993), are likely to require extra processing time and hence storage. Semantically complex sentences such as those where a word could have two possible meanings, e.g. "*Bill wiped the glasses and put them back on*" versus "*Bill wiped the glasses and put them back in the cupboard*", where an unknown word is encountered, or sentences that have many content words e.g. *"Touch the small red circle, after the green triangle"* also require extra processing time. The entire sentence may have to be stored before it can be analysed and understood. The relationship between phonological memory and language comprehension has been examined in persons with and without language impairment.

The phonological loop and sentence comprehension in persons with language-impairment.

The effects of impairment in the phonological loop on sentence comprehension have been explored in persons with acquired brain damage (Gathercole & Baddeley, 1993). Vallar & Baddeley, (1984) examined a patient who appeared to have an impaired phonological loop as evidenced by the small number of items she could immediately recall. As she did not have impaired speech production, however, it was assumed that articulatory rehearsal was intact. An examination of her sentence comprehension revealed that she had difficulty with syntactically complex sentences like passives and sentences with embedded clauses. Vallar & Baddeley (1984) explored the patient's comprehension further and found that she performed well on short sentences even when there was a wide range of syntactic construction. This suggests storage difficulties rather than syntactic difficulties. Likewise she had difficulty with anaphoric references that occurred more than one sentence earlier as she was unable to maintain the earlier sentence in her phonological store.

The role of the phonological loop in sentence comprehension has also been examined in children with developmental language impairment. Montgomery (1995) looked at children with specific language impairment (SLI) and compared them to children without SLI who were matched on sentence-level comprehension abilities. Each group listened to two sentence types: one sentence type contained linguistically redundant information while the other sentence was non-redundant and therefore shorter. An example of the sentences is as follows:

1. *The little boy (who is) standing is hitting the little girl (who is) sitting.* (Redundant)
2. *The little boy standing is hitting the little girl sitting.* (Non-redundant)

In addition, both groups of children were administered a nonsense word repetition task to determine the capacity of their phonological memory. The children with SLI repeated significantly fewer three and four syllable items than the children in the control group. The SLI group also showed a deterioration on repetition of three and four syllable items compared to one and two syllable items. With regard to sentence comprehension, there was no difference between the two groups on comprehension of non-redundant sentences, but SLI children performed significantly poorer on redundant sentences. There was a positive correlation between phonological memory capacity and sentence comprehension (r = .62, p <.01). An examination of individual data revealed that the children with SLI who performed better on the phonological capacity measure also performed better on the sentence comprehension task.

One of the criticisms of Baddeley's working memory model is that the central executive is not well described. Some researchers (e.g. Just & Carpenter, 1992) have attempted to explain the central executive however, and view it as the primary component of working memory. One such model is Just and Carpenter's (1992) model of working memory.

1.3.2 Just and Carpenter's Model of Working Memory

Just & Carpenter (1992) present a unitary model of working memory. Although not a multicomponent model, there are four main processes involved in working memory: storage, processing, activation and resource allocation.

Storage

Storage is an important part of language comprehension as comprehension occurs over time, and therefore products (such as meanings of words) and partial products (e.g. part of a sentence) must be stored while language is being comprehended. Both lexical and discourse comprehension involves working memory. Lexical comprehension occurs when words and phrases are stored and related to upcoming words and phrases. Discourse comprehension involves storage of the theme of the text, the situation to which it refers, major propositions from preceding sentences and multilevel representations that occur through the text (vanDijk & Kintsch, 1983; Kintsch & vanDijk ,1978).

Processing

The concept of processing, in Just & Carpenter's model refers to *computation.* Computations are the symbolic manipulations that are considered cognition. Computations include cognitive manipulations such as "comparison, retrieval, and logical and numerical operations" (Just & Carpenter, 1992, p.123).

Activation

Activation is the fuel that drives storage and processing . Activation is essentially equivalent to working memory capacity (Just and Carpenter, 1992). They state "capacity can be expressed as the amount of activation available in working memory, to support either of the two functions" (p123). The two functions they refer to are processing and storage.

Comprehension of language involves storing and processing elements of a sentence or passage such as words, phrases, grammatical structures, and themes. Just and Carpenter (1992) stated that each element has an activation level. The activation level is the amount of "fuel" needed to access, store, and process information in working memory. An element becomes activated by being seen or heard in spoken or written language, retrieved from long term memory, or by being generated by a computation (Just & Carpenter, 1992). As an element is activated, it becomes a part of working memory and can be stored or operated on (processed further).

If a person is engaged in a language comprehension task, and the total amount of activation (i.e. resources) available is less then is needed to complete the task, either storage or processing may be affected. When storage is affected early elements may be dropped or forgotten

Computation may be affected by limited resources. In lexical processing, activation of a word (e.g. *cat*) may result in partial activation of another word (e.g. *dog*). Similar activation rules occur in syntax processing (Waltz & Pollack, 1985). For instance, presentation of a subject in a sentence will partially activate a verb proposition. While the person is expecting a verb, he or she may be simultaneously processing semantic or pragmatic information (Just & Carpenter, 1992). It is thought that the comprehension processes are occurring in parallel. However, if there are a large number of processes occurring, then there might not be enough fuel available to partially activate upcoming elements. The trade-off that occurs between storage and processing is called resource allocation.

Resource Allocation

Resource allocation is the sharing of fuel or resources among storage and processing functions. Once an activity exceeds the available resources, the resources are scaled back so that either the storage or processing system may lose resources. If the storage system loses the resources, there will be a forgetting of information and if the processing system loses resources then processing will become slower and less efficient. Just and Carpenter (1992) compare this to a budget-cut whereby resources are cut across the board. Resources may be shared equally across the board or allocated differentially. For instance, processing may be favoured over storage. Likewise, certain processes may be favoured over others (Just & Carpenter, 1992). The authors suggest that processes that happen quickly or are more automatic, may be favoured over more strategic processes such as using context to resolve lexical ambiguity.

Just and Carpenter (1992) assert that people with more resources (i.e. larger working memory capacity), will have superior performance on complex language comprehension tasks. Individuals with large and small working memory capacities would not differ on simple comprehension tasks, as the available resources would not be exceeded. Some debate exists as to whether the relatively poor performance by individuals with small working memory capacities is due to poor storage, inefficient processing mechanisms or poor resource allocation (Engle, Cantor, & Carullo, 1993). Just & Carpenter's (1992) model does not distinguish the differences among storage, processing or resource allocation efficiency, and prefer to explain reduced comprehension performance on the capacity available for storage and processing.

Assessment of Working Memory Capacity

If available resources or capacity is considered to be the aspect of working memory that is best able to explain comprehension abilities, then it is imperative that an effective method of assessing capacity is used. Just and Carpenter (1992) measured differences in working memory capacity using a "Reading Span" task (Daneman & Carpenter, 1980). The reading span task targets both storage and processing. Reading span differs from short-term memory recall tasks such as digit span storage and processing occur simultaneously. Individuals with severely impaired performance on a digit span task, can still have preserved sentence comprehension (Shallice, 1988).

During the reading span task, participants read groups of unrelated sentences and recalled the final words of the sentences. In the original span test developed by Daneman and Carpenter (1980), there were three sets each of two, three, four, five, and six sentences. Testing was continued until the person failed all three sets at a specific level. The maximum number of sentences that could be read, and final words recalled in two of the three sets was considered the person's reading span size. In a modified version, the authors presented five series of sentences at each level and working memory span was based on the maximum number of words recalled in three sets out of five. In addition, participants are required to answer yes or no as to whether the sentence makes sense. Answering yes or no prohibited the participants from simply paying attention to the final words.

The usefulness of the Reading Span task was evaluated by administering the task to 20 college students. The results of the Reading Span task were compared to the students' Verbal Scholastic Aptitude Test (SAT) scores, as well as to two measures specific to reading comprehension: answering fact related questions and answering pronominal reference questions. The Reading Span task was related to the students verbal SATs ($r(18) = .59, p < .01$) and even more closely related to the comprehension tests ($r = .72$ for the fact questions, $r = .90$ for the pronominal reference questions). The reading span varied between 2 and 5, and those students with small working memory spans had much poorer performance than those with larger working memory spans. Interestingly, a digit span measure was also taken, however it was not correlated with the Verbal SATs, or the comprehension tests.

A listening version of the Reading Span task was also tested by Daneman and Carpenter (1980) and produced similar results. The test was modified slightly (a true-false component was added, as described above). The test was presented orally. Participants listened to the sentences and were given 1.5 seconds to answer true or false before the next sentence was presented. They found participants with larger listening spans were better comprehenders than those with smaller working memory spans.

Differences in Working Memory Capacity and Language Comprehension in Adults without Brain Injury

To test their theory that working memory capacity affects comprehension, Just and Carpenter (1992) separated college-age adults into two groups; Group 1 comprised adults with high working memory spans and Group 2 were adults with low working memory spans. Group separation was based on the *Reading Span* test. The researchers conducted several sentence comprehension experiments and found group differences in each experiment. The researchers suggested that the experimental results supported a capacity theory of working memory.

Just and Carpenter (1992) demonstrated that people with a high working memory span could activate extra information, such as pragmatic cues, when reading a sentence, whereas individuals with low working memory span could not activate the pragmatic information until the sentence was read a second time. Just and Carpenter presented participants with four different types of sentences:

1) Reduced relative clause sentences with an inanimate subject;

2) Reduced relative clause sentences with an animate subject;

3) Unreduced relative clause sentences with an inanimate object; and

4) Unreduced relative clauses with an inanimate object.

Reduced relative clauses are those that have had the complement and the verb eliminated. For example in the sentence, *"The defendant examined by the lawyer shocked the jury"*, the phrase *"who was"* is not present. The elaborated version would be *"The defendant* ***who was*** *examined by the lawyer shocked the jury"*. In some of the stimulus sentences the subject of the sentence was animate, (i.e. *"The defendant shocked..."*), while in other stimulus sentences the subject was inanimate (i.e. *"The evidence examined..."*). It was predicted that when the subject was animate, the reader would expect the first verb presented after the subject to be considered the main verb. It would become evident to readers that it was not the main verb, however when a phrase "*by the*..." was presented. The need to change one's processing should slow reading times.

On the other hand, when the subject in the sentence was inanimate, the reader should use the pragmatic information (i.e. that an inanimate object cannot engage in an action) and thus the reading time should not be as slowed when they encounter the phrase "*by the*...". The following two examples provide an analysis of such processing.

Example 1:

Stimulus sentence: "*The evidence examined by the lawyer shocked the jury.*"

(inanimate) (1^{st} verb) (main verb)

In this sentence the reader should not have a slowed reading time when reading the phrase by *the lawyer* as pragmatics would indicate that *evidence* couldn't actually perform an action such as examine.

Example 2:

Stimulus sentence: "*The defendant examined by the lawyer shocked the jury*".

(animate) (1st verb) (main verb)

In this sentence the reader will have a slowed reading time because the reader will expect that "*examined*" is the main verb.

Just and Carpenter presented the sentences to 40 readers with high working memory spans (working memory spans of 4.0 or greater) and to 40 readers with low working memory spans (span of 2.5 or less). The dependent variable was reading time which was measured by recording eye gaze at the phrase "*by the*...", at the first verb, and at the main verb. They found that high span readers had slowed processing at the "*by the*..." phrase when the subject was animate but low span readers did not. Hence, high span readers had the resources available to them to activate the pragmatic information, but the low span readers did not. The animacy of the subject affected reading times in both reduced and unreduced relative clauses. Both groups had faster reading times on the unreduced clauses compared to the reduced relative clauses. There were no other interactions found on the reading times of other parts of the sentence (the verbs) so it cannot be accepted that the high span participants were slower readers.

In a second study, Just and Carpenter (1992) explored the effect of working memory span on the comprehension of syntactically complex sentences. They referred to a study by King and Just (1991) that measured reading times of two different types of sentences: object-relative sentences and subject relative sentences. Object-relative clauses are those in which the head noun is the object of the relative clause. Subject-relative clauses are those in which the head noun is the subject of both clauses. For example:

1. *The reporter that the senator attacked admitted the error.*

(head noun)(object-relative clause)

2. *The reporter that attacked the senator admitted the error.*

(head noun)(subject-relative clause)

Just and Carpenter (1992) suggested that the object-relative clauses are more difficult to comprehend because the object relative clause interrupts the main clause. Thus the subject of the sentence must be stored or reactivated at the end of the embedded clause. In addition, the subject in an object-relative clause sentence is both the subject of the main clause and the object of the relative clause, which may cause difficulty with comprehension.

King and Just (1991) presented object-relative and subject-relative clauses to college-age students with high and low working memory spans. The dependent variable was reading time, which was measured by looking at word-by-word self-paced reading times. Hence, the reader controlled his or her reading pace and time spent on each word was recorded. Group differences were noted on the object-relative sentences that supported the theory that working-memory differences will be evident when the task is demanding. Individuals with low working memory spans had slower reading times and performed poorly in comprehending complex sentences. Just and Carpenter (1992) stated that these findings supported the model because there were no group differences on simple sentence tasks but group differences resulted when the task was complex. Hence the individuals with low working memory spans were not simply poor at syntactic processing.

A third study examined the relationship between understanding syntactically ambiguous sentences and working memory capacity (MacDonald, Just, & Carpenter, 1992). A syntactically ambiguous sentence is one in which one aspect of the sentence is unclear (ambiguous) until the entire sentence is read. Examples of syntactically ambiguous sentences used by MacDonald et al. (1992) are as follows:

1. *The experienced soldiers warned about the dangers before the midnight raid.*

2. *The experienced soldiers warned about the dangers conducted the midnight raid.*

Until the entire sentence is read, it is unclear whether the soldiers were doing the warning (as in Sentence 1) or had been warned (as in Sentence 2). It is thought that when a reader encounters a syntactic ambiguity, both possible interpretations are activated (Gorrell, 1987; as cited in MacDonald et al., 1992); thus increasing memory load. It is posited by Just & Carpenter (1992) that individuals with a low working memory span will drop the least plausible interpretation. MacDonald et al. (1992) found that the low-span participants did appear to drop one interpretation, however they had difficulty with comprehension if they dropped the wrong one. The high span readers maintained both interpretations and hence had slower reading times near the end of the sentence. The high span readers did not have slower reading time on the unambiguous sentences. Just and Carpenter (1992) argued that this highlighted the trade-offs between storage and processing and the increased storage demands of the high capacity readers resulted in slowed processing times.

The effects of temporal constraints on understanding sentences complex sentences (Miyake, Carpenter, and Just, 1994) lends further support to a limited capacity model of working memory. Eighty-four college students were separated into high-, mid-, and low-reading span groups. Each group read 176 sentences in 2 blocks. In one block, the sentences were presented at 120 ms/word (fast rate) and in the other block, sentences were presented at 200 ms/word (slow rate). There were 11 sentence types that varied in complexity. After reading each sentence, the participants answered a yes/no comprehension question. High-span readers had better comprehension scores than low-span readers across fast and slow presentations of sentences. In addition, both groups performed better on the slow sentences than the fast sentences. The interaction among speed, sentence complexity, and span however provided the most support for Just and Carpenter's (1992) model. Results showed that syntactically complex sentences were more difficult to understand in the fast condition than in the slow condition. In addition, the more complex sentences were associated with decreased comprehension in individuals with low working memory spans. Finally, faster presentation speed had a greater impact on syntactic comprehension for individuals with smaller working memory spans.

Miyake et al. (1994) pointed out that the study provides support for Just and Carpenter's working memory model because factors that make demands on comprehension such as speed and syntactic complexity affect those with low working memory spans while those with higher working memory spans are not as affected by the higher demands.

Working Memory Capacity and Language Comprehension in Persons with Aphasia

In addition to finding support for their model with participants without impairment, Just and Carpenter found support in studies of persons with aphasia. Miyake et al. (1994) posited that persons with aphasia have reduced working memory capacities compared to non-brain injured people. Because there is reduced working memory capacity, there are trade-offs in storage and processing when comprehension demands become high. Hence there may be a forgetting of information or a slowing down of processing because not as much fuel is available to activate the processes. They supported their view by placing non-impaired adults under high working memory demands and examining their comprehension. They found that the performance of non-impaired individuals under high working memory conditions resembled the comprehension of persons with aphasia.

Thirty-six adults with low- and mid- working memory spans were included in the study. Each subject was presented with sentences of varying complexity at a speed of 160 ms/word. Miyake et al. (1994) found that syntactic complexity was associated with poorer comprehension for both groups. Individuals with mid-span capacity performed better than individuals with low working memory span. More importantly, however, they compared the comprehension profiles of the participants with comprehension profiles of persons with aphasia from another study (Caplan & Hildebrandt, 1988; as cited in Miyake et al., 1994). They found that the results were similar in that participants in both studies (non-impaired in Miyake et al.'s study and aphasic in Caplan & Hildebrandt's study) clustered into three sub-groups although the sub-groups in both studies could not be characterised in any straight forward manner. In addition, participants in both studies made similar kinds of errors.

Summary of Just and Carpenter's (1992) Model

Several important implications result from Just & Carpenter's (1992) model and their experiments. A synopsis of the issues and implications is as follows:

1. Working memory for language comprehension is made up of a pool of resources that fuel storage and processing. The elements that are stored and processed are part of working memory.
2. The capacity of working memory is an important indicator of how well people will comprehend spoken and written language.
3. Working memory capacity can be assessed by using a task that makes both processing and storage demands. Daneman and Carpenter's (1980) Reading Span and Listening Span are measures of working memory capacity.
4. People with lower working memory capacity show comprehension difficulties when the demands of the task are high. Increased processing demands are evident when there is syntactic ambiguity, increased syntactic complexity, and/or increased speed.

5. The comprehension difficulties are a result of trade-offs between storage and processing. Hence, there may be a forgetting of information, or processing may become slowed or not completed.
6. Low working memory capacity may explain the comprehension difficulties of non-impaired individuals as well as persons with brain damage.

The implications are the basis for upcoming studies in the dissertation.

1.3.3 Working Memory Constraints on Comprehension

It is a central argument of Just and Carpenter's (1992) model, that working memory is a limited capacity system used for storing and processing information in language comprehension activities. When the demands of the activities are greater than the available resources, comprehension is compromised because of the storage and processing trade-offs. Just and Carpenter and their colleagues (Carpenter, Miyake, & Just, 1994; Miyake et al., 1994; MacDonald et al., 1992) described several working memory constraints that affect comprehension. Some of the factors include: syntactic and lexical ambiguity, syntactic complexity, temporal constraints, text distance, and external memory load. A sixth factor put forward is one related to automatic versus strategic processing tasks (Granier et al., 2000; Engle et al. 1993).

Syntactic and Lexical Ambiguity

Ambiguous statements are those that have could have more than one possible meaning. Sometimes the meaning can be interpreted by the time the sentence has finished, whereas other sentences may only be interpreted by the non-linguistic information (Nippold, 2000). It is thought that the two or more plausible interpretations are held in storage until enough information is available for one interpretation to be accepted. Just and Carpenter and colleagues studied two types of ambiguous statements: syntactic ambiguities and lexical ambiguities. The MacDonald et al. (1992) study described earlier demonstrated that persons with low working memory capacity were unable to maintain multiple interpretations of sentences that were syntactically ambiguous. Miyake, Just and Carpenter (1995) examined sentences with lexical ambiguities. A lexical ambiguity results when a word in the sentence has two possible meanings. For example:

1. *Since Ken really liked the* ***boxer****, he took a bus to the nearest sports arena to see the match.*
2. *Since Ken really liked the* ***boxer****, he took a bus to the nearest pet store.*

In these sentences, the word "*boxer*" is ambiguous. It is not until the reader finishes the sentence that the meaning of the word can be determined. The two meanings of the word "boxer" are held in working memory until it is disambiguated later in the sentence. The experimental stimuli were sentences where one interpretation was dominant and the other subordinate. Like the MacDonald et al. (1992) study, low span participants dropped the less preferred interpretation. Reading times were measured and as predicted, low span participants had slower reading times on ambiguous sentences with a subordinate interpretation. The slowed reading time was especially evident at the end of the sentence when low span readers would be trying to resolve the conflict in meaning between their interpretation and the meaning implied at the end of the sentence.

Syntactic Complexity

The effects of syntactic complexity on working memory were evident in several of the studies describe by Just and Carpenter (1992) and their colleagues. In the King and Just (1991) study, understanding of the more difficult object-relative clauses versus the simpler subject-relative clauses was shown to put constraints on working memory capacity.

Individuals with low working memory capacities had much slower reading times than individuals with high working memory capacity. A second study described earlier (Miyake et al., 1994), demonstrated how sentences presented at quick rates, became more difficult for individual with low working memory spans when syntactic complexity was increased.

Temporal Constraints

Temporal constraints on working memory refer to a person not having sufficient time to process the information. The study that Miyake et al. (1994) carried out that presented sentences at very rapid rates demonstrated how processing restrictions affected comprehension for individuals with low working memory span. Another much earlier study (Forster & Ryder, 1971), presented sentences rapidly, word by word, on a screen. This study found that participants could recall simple sentences but not complex sentences. Although these participants were not divided into high and low working memory span groups, it does demonstrate that fast presentation of information may obscure understanding and recall.

The manipulation of rate is not clear-cut however. The effect of rate on sentence comprehension by adolescents with brain injury has been examined by Turkstra (1998). Turkstra (1998) administered a standardised receptive language test to 12 adolescents (aged 12 to 21) who had sustained a traumatic brain injury. The test that was administered was the Listening/Grammar subtest of the *Test of Adolescent Language (third edition) (TOAL-3)* (Hammill, Brown, Larsen, & Wiederholdt, 1994). The Listening/Grammar subtest involves having the examinee listen to three sentences and choosing which two of the three mean the same thing. Each subject was administered three versions of the subtest. The three versions varied on temporal conditions. In the first version, the sentences were presented with a short (2 second) break between each sentence. It was predicted that this would increase processing demands because the sentences would have to be understood and compared quickly. The second version presented the sentences with a long break (4 seconds) between sentences. It was predicted that this would reduce storage demands but could increase processing demands. The third version allowed participants to control the rate of presentation that was predicted to minimise storage and processing demands, as participants could replay the sentences. It was expected that participants would perform best on this subtest. In addition, all participants were administered a test that measured working memory capacity. With regard to working memory, performance on working memory tasks was correlated to performance on the long and short interval versions. Surprisingly there was no difference in performance on the test across the three conditions. In addition, nine of the twelve participants preferred the short and long interval versions compared to the variable version. The author suggested that perhaps the additional load of deciding on and controlling the time interval put extra stress on working memory. The author concluded that although it makes sense intuitively to have better performance with slower presentation rate, the trade-offs between storage and processing may reduce the benefits (Turkstra, 1998).

Text Distance

Text distance refers to how long a person can maintain information over an extended text. Text distance usually refers to understanding connected text (i.e. text with several sentences) versus single sentences. Because working memory is a fixed capacity system, a person cannot hold individual sentences in working memory indefinitely. In the model of discourse processing put forward by Kintsch and van Dijk, (1978) and vanDijk and Kintsch (1983), it was pointed out that readers or listeners retained the most recent and central clauses of text. Specific details and words are purged from memory. Another mechanism employed during a comprehension task is to purge certain information, as described in the MacDonald et al. (1992) study.

Text Distance Effects in Non-impaired adults

Individual differences in the ability to store information over a distance in text has been found to be related to working memory span. Daneman and Carpenter (1980) noted a relationship between reading span and the distance across text with which a person could find an antecedent for a pronoun.

Text Distance Effects in Children with Poor Comprehension

Studies of text distance have also been shown to affect comprehension of text in children. Yuill, Oakhill, and Parkin (1989), had children who had poor reading comprehension attempt to resolve anomalies in a text. The authors examined nine skilled readers and nine non-skilled readers. They presented the children with several short stories (6 lines each), concerning an adults response to a child's action. In some stories, the adult's response was inconsistent with what the child would expect. Information that would resolve the inconsistency was presented either before or after the inconsistency. In addition, the resolving information was either near the inconsistent information or separated from it. An example of the stimuli is as follows:

1. Resolving information is *after* and *near* the inconsistent information:

a) Tommy had been out to the sweetshop.

b) Tommy didn't share his sweets with his little brother.

c) When their mother saw this, she was very pleased with Tommy (inconsistent information).

d) Tommy's brother was very fat and he was on a diet (resolving information).

e) Tommy got out his train set.

f) He played with the trains all morning.

2. Resolving information is *before* and *near* the inconsistent information:

a) Tommy had been out to the sweetshop.

b) Tommy didn't share his sweets with his little brother.

c) Tommy's brother was very fat and he was on a diet (resolving information).

d) When their mother saw this, she was very pleased with Tommy (inconsistent information).

e) Tommy got out his train set.

f) He played with the trains all morning.

3. Resolving information is *after* and *separated* from the inconsistent information.

a) Tommy had been out to the sweetshop.

b) Tommy didn't share his sweets with his little brother.

c) When their mother saw this, she was very pleased with Tommy (inconsistent information).

d) Tommy got out his train set.

e) He played with the trains all morning.

f) Tommy's brother was very fat and he was on a diet (resolving information).

4. Resolving information is *before* and *separated* from the inconsistent information:

a) Tommy's brother was very fat and he was on a diet (resolving information).

b) Tommy had been out to the sweetshop.

c) Tommy didn't share his sweets with his little brother.

d) When their mother saw this, she was very pleased with Tommy (inconsistent information).

e) Tommy got out his train set.

f) He played with the trains all morning.

Following the presentation of each story, the children were asked whether Tommy should have been blamed or praised for his actions. The less skilled readers were significantly worse than the better readers at resolving the ambiguity when the resolving information was separated from the inconsistent information. The position of the resolving information (before or after the inconsistent information) did not make a difference to comprehension.

Text Distance Effects in Adults with Brain Damage

Text distance has also been shown to have an effect on comprehension in adults with right hemisphere brain damage (RHD) (Lehman-Blake & Tompkins, 2001). The ability of adults with RHD to generate inferences was studied. Twelve adults with RHD and eleven adults with no brain damage were given several short stories to read. The stories were made up of five sentences. Three of the sentences described the setting and one sentence predicted an outcome. Lehman-Blake and Tompkins (2001) also included a sentence that disconfirmed the prediction. An example of a paragraph is as follows:

a) Tim set out his jacket and cap.

b) He had been looking forward to this trip for months.

c) Tim had been busy at work and wanted some time alone.

d) He put his rod in the car and drove to the lake. (predictive sentence) *e) He couldn't wait to go skiing by himself.* (disconfirming sentence)

The dependent variable was reading time. Inference generation was thought to take place when reading times were slowed. If the reader had used the predictive information to make an inference, the disconfirming sentence would take longer to resolve. Two story conditions were presented. In one condition, the predictive utterance was near the disconfirming utterance (as in the example above). In the second condition, the predictive utterance was distant from the disconfirming sentence. Lehman-Blake and Tompkins (2001) found that individuals with RHD had slower reading times when the predictive sentence was near the disconfirming sentence than when it was distant, suggesting that inferences in the recent condition were more strongly activated. The authors also compared the distant condition reading times to a control passage that did not require the participants to make an inference. They found that only half the RHD group had slowed reading times on the distant condition passage, suggesting half of the group did not maintain the inference. There were no group differences in reading times when only the recent condition was examined. This suggests that although people with RHD can generate inferences, some are not able to maintain the inference over time.

External Memory Load

External memory load refers to a secondary task that is carried out during comprehension that shares the working memory resources. External memory load tasks are commonly referred to as dual-tasks. The effect a secondary task has on a primary task depends on what the primary task is (Carpenter et al., 1994). A small external load will have a larger effect when the primary task is a demanding task such as comprehending complex sentences versus comprehending simple sentences.

External memory load in non-impaired adults.

The addition of an external memory load was seen in the study carried out by King and Just (1991) involving comprehension of subject-relative and object-relative clauses. Although individuals with a high working memory span could comprehend object-relative clauses, the addition of an external load such as remembering one or two unrelated words, resulted in impaired performance.

A different type of external memory load was used in a study by Granier, Robin, Shapiro, Peach and Zimba (2000). A visuomotor tracking task was used during a sentence comprehension task. The participants listened to 150 sentences. For some of the questions they were just required to listen to the sentence and for some they were required to answer a yes/no comprehension question. While performing the comprehension task, participants were required to track the movement of a target on a screen. It was predicted that there would be interference across the tasks when the participants had to answer the yes/no questions, as more resources would be required for decision making and formulating a response. Granier et al. (2000) found that comprehension was not compromised but performance on the visuomotor task deteriorated when participants had to respond to a yes/no question. In this study, external load did not affect comprehension, but increased demands in the primary task affected the secondary task. It is important to recognise that the secondary task was non-verbal and yet the comprehension task and tracking task appeared to share resources. There is debate in the literature whether visual and verbal tasks share resources. This will be discussed in a later section.

External memory load and persons with brain damage

A study of sentence comprehension in adults with Parkinson's Disease (PD) was carried out (Seidl, Onishi, White, D'Esposito, & Grossman, 1994). The investigators examined understanding of sentences with subject-relative and object-relative clauses. During the comprehension task, participants were given a secondary task that varied in terms of the external load it placed upon their working memory. It was found that with a reduced external load, individuals with PD had better sentence understanding.

The effects of external memory load on a semantic comprehension task were examined in persons with aphasia (Murray, Holland, & Beeson, 1999). Participants were engaged in a lexical decision task where they looked at words and non-words and determined which was real. Participants performed the task in isolation, as well as with a non-verbal distracter (tone) and a verbal distracter (semantic judgment) task. The distracter tasks were presented simultaneously with the lexical task and the subject was required to do either, *a)* attend only to the lexical task or, *b)* do one task and then the other. There were no group differences when the task was performed in isolation. When an external load was added, the persons with aphasia performed more poorly on the lexical decision task. Both groups performed better when the distracter was non-verbal.

Working Memory Load and Individuals with TBI

There have been very few studies that have examined the effects of working memory on individuals with TBI. Two studies that have examined working memory and comprehension in TBI, have evaluated comprehension in relation to working memory load. Turkstra & Holland (1998) administered the Listening Grammar subtest of the *TOAL-3* to six brain-injured adolescents and six hospitalized control participants, matched for age, sex, and general ability. The Listening Grammar subtest requires examinees to listen to three sentences and determine which two are similar in meaning. The participants were administered the original Listening Grammar task, along with a modified version which presented fewer response choices, hence decreasing both processing and storage load. Individuals with TBI performed significantly better on the task when the storage load was reduced. Control participants did not demonstrate any difference in performance across tasks. In addition, participants completed a working memory measure and a significant difference was found between the adolescents with TBI and the matched controls.

A second study examining the effects of working memory load on individuals with TBI looked at children's ability to understand anomalous sentences (Hanten, Levin, & Song, 1999). Twelve children with TBI (mean age = 10.03 years) were presented with 32 anomalous sentences; 16 with syntactic anomalies (e.g. "*The girl dried himself*") and 16 with semantic or pragmatic anomalies (e.g. "*She threw the fried boots in the garbage*"). For the semantic anomalies, half the sentences contained the anomaly before the verb (e.g. "*The fried boots, she threw into the garbage*"), and half contained the anomaly after the verb. It was predicted that children with TBI would be able to identify the anomaly in a sentence more easily when it was presented after the verb as the anomaly would not have to be stored in working memory. The hypothesis was confirmed and, in addition, a correlation was found ($r = .63, p < .02$) between performance on a working memory measure and performance on the sentence anomaly task. The author's concluded that this supported a hypothesis that working memory contributes to the language impairments that result from a TBI.

Automatic Processing versus Strategic Processing

It has been proposed that some language processing tasks occur automatically and use very few resources while other tasks are controlled and strategic and use more resources (Granier et al., 2000). Granier et al. (2000) describe automatic tasks as those that "occur fast and early, and are initially independent of context…" (p. 502) whereas strategic processes take longer, require integration of information and depend on context and world knowledge. An example of an automatic process is lexical access. In the study described earlier by MacDonald et al. (1992) it was proposed that when a word was presented all possible meanings were activated. Another example of an automatic process is the activation of verb-argument structure (Granier et al., 2000). Shapiro, Zurif, and Grimshaw (1987) demonstrated that when a verb was encountered all of its possible argument structures are activated even when the sentence was biased toward one set of argument structures. Strategic processes in sentence comprehension include lexical selection (i.e. choosing the appropriate meaning of a word from all possible meanings dependent on the context) and end-of –sentence wrap up (integrating all aspects of the sentence to establish one meaning). Granier et al. (2000) suggest that even the tasks we use to assess comprehension also involve controlled, strategic processes. They argue that tasks such as sentence-picture matching, lexical judgements, and responding to questions all strategic, integrative processing tasks that require extra resources. These resource-consuming comprehension tasks as referred to as off-line tasks (Granier, et al., 2000; Shapiro, Swinney, & Borsky, 1998). The alternative to off-line tasks of comprehension are on-line tasks of comprehension. On-line tasks measure comprehension while it is occurring rather than after it has occurred. Whereas off-line tasks necessarily involve strategic processing and make extra demands on working memory, on-line tasks are sensitive to automatic processing as well. On-line tasks are used to measure the processing that is occurring at different points during the sentence or discourse. On-line tasks may include assessment of reading times (e.g. Lehman & Tompkins, 2001) or priming tasks. In addition to more accurate measurement, on-line tasks have been useful for evaluating which processes are fast and automatic, requiring few resources, and which are slow and strategic and require greater resources.

One type of language processing task that varies in terms of automaticity is inference understanding (McKoon & Ratcliffe, 1982). Inference understanding is particularly interesting in relation to TBI because it has been found to be impaired in children and adults following head injury (Dennis & Barnes, 1990; Hinchliffe et al., 1998;Jordan & Murdcoh, 1994?). An inference was defined by McKoon and Ratcliffe (1992) as "any piece of information that is not explicitly stated in a text" (p.440). Therefore an inference involves using the information that is explicit and filling in that which is intended but not made explicit. Examples of inferences, according to the authors' definition, would include pronoun references (e.g. When the word "*she*" is encountered it refers to someone already mentioned), references that use two different words to refer to the same concept (e.g. A dog may be mentioned and then reference to "*the collie*" would be made and the reader/listener would have to infer that the same animal is being discussed), bridging inferences (e.g. A reader might encounter "*The man dropped the valuable vase. He swept up the shattered pieces*" and would have to infer that the vase broke) and predictive inferences (e.g. A reader might encounter "*The children jumped into the car with their bathing suits and towels*", and have to predict that the children were going swimming).

McKoon and Ratcliffe (1992) noted that some inferences are automatic and occur very quickly, while some involve more elaborative processing. They identified three factors that relate to the automaticity of inferences: explicit mention of the information in the text, necessity of understanding the inference for comprehension, contextual bias and familiarity.

Explicit information in the text

Explicit mention of the information in the text relates to references like pronoun references where the referent is stated somewhere in the text. These types of inference do not rely on world knowledge for them to occur. Inferences such as bridging or predictive inferences, on the other hand, do not explicitly mention the inference and often depend on world knowledge.

Necessity for comprehension

Necessity for comprehension is another factor that is likely to make certain inferences more automatic (McKoon & Ratcliffe, 1992). Necessity for comprehension refers to whether or not understanding of a passage relies on the inference being made. For instance, it is necessary to understand what a pronoun is referring to in a sentence. Likewise, in the example of a bridging inference described above, it would be necessary for the reader/listener to infer that the vase broke. Predictive inferences on the other hand are not necessary for comprehension. In the example given earlier, it is not necessary for the reader/listener to infer that the children are going swimming to understand the sentence.

Familiarity

Familiarity is also thought to improve automaticity of inference comprehension. Familiarity is likely to affect all types of comprehension. That is, familiar scripts will be easier to comprehend than unfamiliar scripts and familiar terminology will be easier to understand than unfamiliar terminology. Related to inferences, McKoon and Ratcliffe (1990) show that well-known information based on semantic associations such as "*chair-sit*" are understood very quickly. In a series of studies, Yekovick, Walker, Ogle, and Thompson (1990) demonstrated that domain-knowledge was related to the quickness and ease of generating inferences in spoken discourse.

Most of the studies discussed in this section have been related to one type of language comprehension: understanding inferences. Automaticity may be harder to manipulate in experiments however increasing automaticity should be considered when examining ways to facilitate comprehension.

Summary

In summary, there are numerous factors that put constraints on working memory and may affect comprehension. The factors discussed in this section include:

1. Lexical and syntactic ambiguity;
2. Syntactic complexity;
3. Temporal constraints;
4. Text Distance;
5. External Memory Load;
6. Automatic versus Strategic Processing;
7. On-line versus off-line tasks.

1.3.4 Measuring Working Memory

There are numerous examples in the literature of ways of measuring working memory. The measures described here include measures of the phonological loop and measures of working memory span that have been derived from Daneman and Carpenter's (1980) working memory span measures (Listening Span and Reading Span). An overview of some alternative measures to the span tasks is also included.

Measuring the Phonological Loop

The phonological loop is the part of working memory that stores verbal information. One way of measuring the phonological loop is to examine how many elements a person can remember and repeat back. It was noted however that the capacity of the phonological loop is affected by the rate of pronouncing the items (Baddeley et al., 1975). Thus one must be careful in choosing the items to be remembered. One very common measure of the phonological loop is the Digit Span task. Digit span tasks involve having a person listen to a sequence of digits and repeat them back. The task usually starts with the person hearing just two digits and it gradually increases in length. The Digit span task is also considered a measure of short-term memory and is included in the Wechsler Memory Scales (WMS) (Wechsler, 1997, 1987). There have been measures of the phonological loop that have been used that have the same premise as the digit span. For instance, Gathercole and Baddeley (1990) measured the phonological store component of the loop in children with specific language impairment. They used a nonsense word repetition task. The children demonstrated greater difficulty with three and four syllable words than one and two syllable words, indicating a reduced phonological store.

The problem with using digit span or measures like it for measuring working memory capacity, is that digit span measures the storage component of working memory only. Daneman and Carpenter (1980) came up with a working memory measure that evaluated both storage and processing. They called these tests the working memory span tests. The written version of the test was called the Reading Span and the auditory version was called the Listening Span. The Reading and Listening Span (Daneman & Carpenter, 1980) have already been discussed in section 3.3.2. It will be reviewed briefly and then a discussion of measures deriving from it will be discussed.

Working Memory Span Measures

Daneman and Carpenter's Reading and Listening Span

Daneman and Carpenter (1980) developed a task that would assess storage and processing simultaneously. In the reading span version, participants read groups of sentences, demonstrated understanding of the sentences and remembered the last word of each sentence. The persons reading span reflected the number of words that could be recalled after reading the group of sentences. Therefore if a person could read a series of 6 sentences and recall all six words, then they would have a Reading Span of 6. The same task was used for Listening Span except it was presented auditorily. The mean Reading and Listening spans were approximately 3, but they ranged from 2 to 5 for their college-age participants. A number of other span tasks based on Daneman and Carpenter's original task have been developed and are discussed in the upcoming sections.

Turner and Engle's Operation Span Task

The Daneman and Carpenter (1980) Reading Span and Listening Span tests are essentially two tasks: one a storage task (i.e. remembering the final words of a sentence) and one a processing task (i.e. comprehending sentences) (Turner & Engle, 1989). Turner and Engle (1989) suggested that when measuring capacity, the type of processing task should not matter. They argue that if one is measuring the capacity of working memory then as long as the task shares the working memory resources between storage and processing, it should be an adequate measure. Turner and Engle (1989) tested their hypothesis. They examined 243 university students. Each student carried out several tasks: four complex working memory span tasks (e.g. the Daneman & Carpenter, 1980) task, two simple span tasks (e.g. the digit span task) and a reading comprehension test. The two simple span tasks involved listening to, and reading, words or digits. The number of items to be remembered gradually increased. Participants had to recall as many of the items they could remember. The four complex working memory span tasks involved:

1. Comprehending sentences and remembering the final words (sentence-word span)(same as Daneman & Carpenter (1980);
2. Calculating simple mathematical operations and then remembering a word (operation-word span) (same as Daneman & Carpenter except mathematical "sentences" were used);
3. Comprehending sentences and remembering digits (sentence-digit span).
4. Calculating simple mathematical operations and then remembering digits (operation-digit span).

Turner and Engle (1989) found that all the complex span measures were correlated with reading comprehension and verbal SAT scores. The correlations were twice the size however, when words were remembered as opposed to digits. The simple span tasks were not correlated with reading comprehension or verbal SAT scores. Not surprisingly the operation-word span and the sentence-word span were highly correlated. This lead to the conclusion that the operation-span task is as useful for measuring working memory capacity as Daneman & Carpenter's Reading and Listening Span task.

Tompkins et al. (1994) Measure of Working Memory

A number of researchers have adapted Daneman and Carpenter's (1980) working memory span to better suit the population they are investigating (e.g. Gaulin & Campbell, 1994, Tompkin, Bloise, Timko, & Baumgaertner, 1994). Tompkins et al. (1994) adapted the Listening Span task for persons with Right Hemisphere Damage. The stimuli are 42 simple declarative sentences. The examinees listen to the sentences and judge whether they are true or false. They are also required to remember the final word. The sentences are based on common knowledge (e.g. "*You sit on a chair*") so do not make excessive processing demands. To maximise the opportunity for storage and processing to occur together, the truth value cannot be established until the final word. The sentences are presented in groups of two, three, four, and five. The working memory capacity score was based on the number of words correctly recalled. Tompkins et al. (1994) examined the psychometric properties of their working memory span task and found that like Daneman and Carpenter's (1980) task, it was poorly correlated with word span. Hence, the authors confirmed that they were measuring something other than storage alone. In addition, test-retest reliability was examined on a small group of participants. When administered the test eight days later, participants made 92% of the errors they had made previously. Two control participants tested 18 months later had nearly identical scores. It is useful to consider measures other than Daneman and Carpenter's original task for assessing children or people with neurological impairments. For instance, Tompkins et al. (1994) task is slightly shorter and the sentences are shorter and simpler. There is a caveat in making the processing portion of the task too easy or too hard. Turner and Engle (1989) found when they tested their complex span measures that when the processing task was of moderate difficulty, the correlations between span and reading comprehension were highest. When the processing task was very simple or very difficult, the correlations became weaker. Perhaps the only way to be certain that Tompkins et al.'s (1994) task, and other tasks developed are equivalent to Daneman and Carpenter's (1980) task is to test it directly and compare it to other known measures of working memory.

Additional Working Memory Measures

Visuospatial Span

The spatial span task is a task meant to measure the span of the visuospatial sketchpad. The spatial span task on the *Wechsler Memory Scale-III (WMS-III)* (Wechsler, 1997) is an example of a visuospatial task. The task in the *WMS-III* is analogous to the digit span task. There are two components in the spatial span task. The first involves the examinee watch as the examiner points to blocks on a board. When the examiner finishes pointing, the examinee does the same. The number of blocks the examiner points to is gradually increased. This should measure the span of the visuospatial sketchpad. The second component of the task again has the examiner pointing to blocks but the examinee must point in the reverse order. This is meant to increase the processing portion of the task and make it nearer to a working memory span task. Whether or not the backward spatial span measures processing is debatable however. It is useful to examine spatial span for two reasons. First, if one accepts Baddeley's (1986) model of working memory then it provides a measure of the visuospatial sketchpad. Secondly, if one accepts there is a general pool of resources for both verbal and visual processing and storage, then measures of spatial and verbal span should be highly correlated.

Stroop Test

The Stroop test (Stroop, 1935; as described in Anderson 2000) is a tool commonly used in psychology experiments. The task involves looking at printed words but rather than reading the word, the subject names the colour of ink the word is printed in. The word may be a neutral word such as "*bed*" or the name of a colour such as "*red*". When a person encounters a colour word (e.g. "*red*") that is written in a different colour ink (e.g. blue), the amount of time it takes for them to name the ink is significantly greater than for words that are neutral or are congruent (i.e. the word is "*red*" and the ink is red).

1.4 Summary and thesis aims

Significant advances have been made in the understanding of traumatic brain injury in recent years. Academic and language impairment in adolescents who have sustained a traumatic brain injury have been documented. There is debate, however, as to the nature of the deficit.

There are a number of issues raised by the literature that may be contributing to the uncertainty regarding linguistic impairment in adolescents following TBI:

1. Few studies have examined adolescents with TBI as a separate group despite evidence that adolescent language differs from the language of children and adults. Of those studies that did examine adolescents separately the time of injury may have affected the results (e.g. Ewing-Cobbs et al., 1987; Turkstra, 1999).

2. Identification of language impairment in adolescents with TBI may be related to the tasks used. The literature has begun to demonstrate that language tests that assess higher language functions are more sensitive to deficits following TBI (Hinchliffe et al., 1998). Language assessment difficulties are further compounded for adolescents, as there is a paucity of assessments aimed at that age group. Lack of assessments is due in part to limited information regarding normal adolescent language development. This is particularly true in New Zealand.

3. Language comprehension in TBI receives little attention despite its importance for academic and social competence. Recent literature has focused more on discourse production in children and adolescents with TBI, despite evidence to show that language comprehension deficits can be identified on certain measures.

4. The language deficits associated with TBI have been attributed to a general theory of cognition, however the theory has not been clearly described and has been challenged by some investigators (e.g. Hinchliffe et al., 1998). Memory is affected in adults and children with TBI. Auditory comprehension has been found to be strongly correlated with

neuropsychological measures of memory. Working memory is associated with comprehension in adults with and without brain injury. There has been limited research looking at the relationship between working memory and comprehension in individuals with traumatic brain injury.

The literature raises a number of issues to be addressed. The aim of the thesis at a general level is to examine the comprehension abilities of adolescents with TBI. Important questions to clarify the nature of comprehension deficits in adolescents with TBI have arisen from the literature and are addressed here. The questions are:

1. How do the listening comprehension profiles of adolescents with TBI compare with the language comprehension profiles of non-impaired adolescents?

2. How does the performance of adolescents with TBI on higher-order language tasks such as figurative language comprehension and inference comprehension compare with typically developing adolescents?

3. What is the nature of the relationship between listening comprehension and working memory in adolescents with TBI?

Specifically, the listening comprehension profiles of adolescents with TBI are examined using a battery of language tests that have been identified as targeting the language forms that have been shown to develop in TBI. In addition, memory profiles, based on New Zealand normative estimates are examined, and the relationship between working memory and listening comprehension is explored.

Three studies that follow examine language forms that have been identified as impaired in individuals with TBI (e.g. Hinchliffe et al., 1998; Jordan et al., 1996): comprehension of inferences and comprehension of figurative language. The literature regarding comprehension of inferences and figurative language in individuals with TBI is inconsistent. Task differences that influence working memory may contribute to the inconsistencies. Three experiments are carried out that manipulate working memory variables that can constrain or facilitate comprehension. In addition, the relationship between working memory as measured by two different tasks and comprehension is explored.

CHAPTER 2: MEMORY PERFORMANCE IN NEW ZEALAND YOUTH

2.0 Introduction

Working memory is related to both spoken and written language comprehension (Daneman & Carpenter, 1981; Just & Carpenter, 1992). Examination of working memory, therefore, is imperative when assessing language comprehension in individuals with TBI as impairment in verbal working memory may result from brain injury (Hartley, 1995). There are a number of experimental measures of working memory (e.g. Baddeley, Della-Salla , Gray, Papagno, & Spindler, 1996; Daneman & Carpenter, 1980; Turner & Engle, 1989), however relatively few normative data are available. One measure that has been standardised for American individuals is the *Wechsler Memory Scale-Third Edition* (*WMS-III*) (Wechsler, 1997). The *WMS-III* is a commonly used clinical tool that is comprised of a battery of subtests measuring different aspects of memory, including auditory memory, visual memory, and working memory. It was developed for older adolescents and adults, aged 16 to 89 years of age.

One of the additions to the third edition of the WMS is the Letter-Number Sequencing subtest, which is measure of working memory using auditory stimuli. The Letter-Number Sequencing test is unique in that it involves both storage and processing to complete the task. Measures used in an earlier version (*Wechsler Memory Scale-Revised (WMS-R)* (Wechsler, 1987), evaluated "lower-level attentional measures" (Wechsler, 1997, p.18), as opposed to a working memory measure. This is problematic because although short-term memory was assessed, no standardised measure of working memory was available.

Clinically available batteries for children under 16 years do not measure working memory. A commonly used memory test for children is the *Children's Memory Scale (CMS)* (Cohen, 1997). Like the *WMS-R*, the *CMS* provides an attention/concentration score rather than a working memory score. Correlation between the Working Memory Index of the *WMS-III* and the *CMS* was 0.68. This moderate correlation (Cohen, 1988), suggests that the two tests are measuring similar constructs but they are not identical measures. For the purposes of examining working memory specifically, the *WMS-III* may be a more useful measure, but understanding how adolescent and children younger than 16 years perform on this test is necessary. Thus, prior to administering the *WMS III* as a measure of memory performance in New Zealand adolescents with TBI aged between 12 – 16, (the population of interest in this thesis) the appropriateness of the *WMS III* for younger adolescents must be established.

The aim of this study was to generate normative estimates for New Zealand adolescents aged 12 to 15 years on the *WMS-III* so that a single test measuring working memory could be used to examine the memory profiles of the adolescents with TBI that are presented in Chapter 3.[1] In addition to generating normative estimates, this study also examined the development of working memory in early adolescence to provide a basis for comparison of working memory development in a disordered population.

[1] Permission was granted by the publishers of the WMS III for the examiner to use the test to gather normative estimates for population samples not included in the published test.

2.1 Test Description

2.1.1 Subtest Description

The *WMS-III* (Wechsler, 1997) comprises 10 primary and 7 supplementary subtests. The primary subtests examine immediate memory (visual and auditory), delayed memory (visual and auditory) and working memory (visual and auditory). The primary subtests also examine memory for recall and recognition memory. A description of the primary subtests is found in Table 2.1.

Table 2.1 *Description of primary index subtests of the WMS-III*

Subtest	Description
Logical Memory I	Two stories are read to the individual who must recall each story immediately after it is heard. The second story is told twice and the examinee is asked to retell it after each presentation.
Logical Memory II (Recall and Recognition)	25 to 35 minutes after the initial presentation of the stories (in the Logical Memory I subtest), the examinee is asked to recall the stories again. The stories are not reread at this stage. In another task (Logical Memory II Recognition), the examinee is asked yes/no questions to determine how well they remember the facts of the story in a recognition task.
Verbal Paired Associates I	The individual is asked to learn pairs of unrelated words. A list of unrelated words is read to the examinee. After five seconds, one word from each pair is presented and the examinee must say what word went with it. The paired word lists are presented four times and after each presentation, the examinee is asked to recall which words went with the presented words.

Verbal Paired Associates II (Recall and Recognition)	25 to 35 minutes after the initial presentation of the paired words (in the Verbal Paired Associates Test I), the examinee is given one word of each pair and asked to recall which word goes with it. In the recognition subtest, they are read 16 pairs of words (8 previously presented pairs and 8 new pairs) and asked whether they heard the pair presented before.
Faces I	The individual is presented with 24 photographs of faces for 2 seconds at a time. Following presentation of the faces, the examinee must look at 48 photographs and determine which faces were already presented. Half of the 48 faces are new to the examinee.
Faces II	Photographs of 48 faces (24 target faces and 24 new faces) are presented to the examinee 25-35 minutes after the presentation of the 24 target faces (in the Faces I subtest). Examinees are asked to look at each of the 48 faces and remark whether or not the face had been presented earlier.
Family Pictures I	The examinee is presented with a portrait of a family (grandfather, grandmother, father, mother, son, daughter, and dog). They are then presented with four different scenes involving various family members. After being presented with all four scenes, the examinee is asked to recall who was in the scene, the location of the family members in the scene, and what activity each person was engaged in.
Family Pictures II	25 to 35 minutes after being shown the family scenes (in Family Pictures I subtest), the examinees are again asked who was in the four scenes, what the location of the family members was in the scenes, and what each member was doing in the scenes. The scenes are not

	presented again in this subtest.
Letter-Number Sequencing	The examinee listens to strings of letters and numbers of increasing length. After each presentation of a letter-number string, the examinee is asked to recall it but to say the numbers first in order from lowest to highest, and then to say the letters in alphabetical order.

Spatial Span (Forward and Backward)	There are two parts to this subtest: forward spatial span and backward spatial span. The tester points to blocks in various orders and with increasing length (i.e. the tester starts off pointing at 2 blocks and gradually increases to 8 blocks). In the forward task, the examinee must point to the blocks that the tester pointed to. In the backward task, the examinee must point to the blocks after the tester but in the opposite order to which they were presented.

The composite scores of primary subtests result in eight possible memory indices (see Table 2.2), referred to in the technical manual as the Primary Memory Indexes (Wechsler, 1997). The eight indices make up the primary scores for evaluating memory function. Scores are calculated for immediate memory (that information that is recalled immediately) and delayed memory (information that is recalled 25 – 35 minutes later). In addition, the indices are divided into auditory memory (for information that is spoken) and visual memory (for pictured information). Finally a recognition index is also included to determine a person's ability to recognize information rather than recall it from memory. This index is included to assist in identifying retrieval problems that may be affecting memory scores on the free recall tasks. An outline of the Primary Memory Indexes and the subtest scores that make up those Indexes is found in Table 2. 2.

Table 2.2 WMSIII Primary memory indexes and the subtest scores.

Memory Indices	**Subtest Composites**
Auditory Immediate Memory	Logical Memory I (Recall) + Verbal Paired Associates I (Recall)
Visual Immediate Memory	Faces I (Recognition) + Family Pictures I (Recall)
Immediate Memory	Logical Memory I (Recall) + Verbal Paired Associates I (Recall) + Faces I (Recognition) + Family Pictures I (Recall)
Auditory Delayed Memory	Logical Memory II (Recall) + Verbal Paired Associates II (Recall)
Visual Delayed Memory	Faces II (Recognition) + Family Pictures II (Recall)
Auditory Recognition Delayed	Logical Memory II (Recognition) + Verbal Paired Associates (Recognition)
General Memory	Logical Memory II (Recall) + Verbal Paired Associates II (Recall) + Faces II (Recognition) + Family Pictures II (Recall) + Logical Memory II (Recognition) + Verbal Paired Associates (Recognition)
Working Memory	Letter-Number Sequencing + Spatial Span

There are five supplementary subtests in the *WMS-III* (Wechsler, 1997). One supplementary subtest, Digit Span, was included in the normative data sample. Digit span is a commonly used measure of short-term and working memory and so was included for comparison purposes. The Digit Span Test is the verbal equivalent of the Spatial Span test, which is one of the primary subtests of the *WMS-III*. The Digit span subtest involves having the examinee listen to strings of numbers of increasing length and repeating them. This is considered to be a measure of short-term memory. The Digit Span Backward portion of the subtest is the same as the forward subtest except the examinee must recall the digits in reverse order. This is often used as a measure of working memory.

A full description of the Primary and Supplementary subtests can be found in the Administration and Scoring Manual of the *WMS-III* (Wechsler, 1997). In addition, a full description of the Primary Indexes and the supplementary indexes is contained in the manual.

2.2 Method

2.2.1 Participants

<u>Participant Description</u>

The sample population was drawn from schools in Christchurch and surrounding areas. Eighty adolescents, aged 12 to 15 years participated in the study. Thirty-four males and 46 females participated in the study. The majority of participants were New Zealand Europeans (90 %). In addition, 1% of the population was NZ Maori, 7% was of Asian descent, and 2% were of Pacific Island descent. A range of socioeconomic groups was represented; 26% were from high socioeconomic areas, 63% were from middle socioeconomic areas, and 11% were from low socioeconomic areas. Participant numbers and average ages within each age group are presented in Table 2.3

Table 2.3 Participant numbers and average ages within each age group.

	12 Yrs	13 Yrs	14 Yrs	15 Yrs
Number	20	22	18	20
Mean Age*	12.05	13.06	14.04	15.06

**Years/months.*

Participant Recruitment

Letters were sent to all state secondary schools in Christchurch and to some secondary schools in surrounding areas requesting their participation in the study. Two primary schools were also approached in order to assess 12- year old students. The researcher visited the schools that agreed to participate and distributed parent consent forms to the principal or relevant contact person who distributed them to various classrooms. As the age range requested was 12 to 15 years, consent forms were distributed to Year 8, 9, 10, and 11 classrooms. Only those students who returned consent forms signed by their parents participated in the study.

Exclusionary Criteria

The exclusionary criteria were based on the standardisation sample for the *WMS-III as* appropriate to a 12- 15-year-old population. Participants were excluded on the following criteria:

- Uncorrected hearing loss
- Uncorrected visual impairment
- Known medical or psychiatric condition that could affect functioning on the test
- Upper extremity disability that would affect motor performance.
- Evidence or diagnosis of speech and language disorders

2.2.2 Procedures

Examiner

The author tested all the participants in the study. The examiner was registered with the Psychological Corporation in Australia to administer the *WMS-III* for research purposes. The examiner administered the *WMS-III* to a group of adults without impairments prior to administering the test to the study's participants, in order to ensure consistent and accurate administration.

Participants in the study were tested individually in a quiet room at their school. The test was administered in strict accordance with the standard procedures described in the Scoring and Administration Manual of the *WMS-III* (Wechsler, 1997). All testing sessions were audio recorded using a Sony TCM-5000EV audiocassette recorder. Participants were assigned a number so that no identifying data appeared on the record form. All primary subtests were administered as well as one supplementary subtest (Digit Span). The subtests were administered and scored according to the administration and scoring criteria in the test manual. Total administration time was approximately 45 minutes.

Reliability of Scoring

As reported in the Technical Manual, scoring criteria for the *WMS-III* is straightforward and inter-scorer agreement is very high (averaging in the high 90's) (Wechsler, 1997). Four subtests, (Logical Memory I and II, and Family Pictures I and II), however, require more subjective scoring and although strong inter-scorer agreement was also reported for these subtests in the manual (reliability co-efficient = 0.90) (Wechsler, 1997) independent reliability for the scores in the current study were calculated. The scores recorded by the examiner on these four subtests from the participant's responses were first checked with a clinical psychologist and scores agreed upon. A trained examiner then independently marked a random selection of 10% of the responses from these subtests. A reliability co-efficient between the two sets of scores was 0.96 for Logical Memory I and II, and 0.95 for Family Pictures I and II. In addition, 10% of the data was drawn at random and checked for scoring errors. No errors were found.

2.3 Results

Means and standard deviations were calculated for all subtest scores for participants in each age group. The distribution of the data was evaluated for normalcy. Scores for subtests that did not have a normal distribution were transformed using Square-root or Base Log 10 transformations and re-examined. Table 2.4 outlines means and standard deviations for all subtests across the age groups.

Standard scores were derived from frequency distributions at each age band. After standard scores were calculated, the standard scores were transformed to Scaled Scores using the formula (z*3) + 10. This produced a normal distribution with a mean of 10 and a standard deviation of 3 and is consistent with the methods used in the original standardisation of the *WMS-III* (Wechsler, 1997). Tables of standard scores and scaled scores can be found in Appendix A.

Composite subtest scores were calculated by adding standard scores of the subtests. For each age group, the means and standard deviations of the composite scaled-score distributions were calculated the and the composite standard scores were transformed to composite Scaled Scores using the formula (z*15) + 100. .The scaled composite scores are reported in Appendix B.

Table 2.4 *WMSIII - Means, Standard Deviations and Ranges for Raw Scores of Primary Index Subtests.*

	LM I	Faces I	VPA I	Fam Pic I	Let Num	Spat Span	LM II
12 Year Olds							
Mean	30.80	35.50	19.05	46.90	9.15	15.05	19.10
Std Dev	11.27	3.24	8.45	8.85	2.06	3.20	7.23
Range	16 - 59	30 - 43	5 - 30	29 - 59	5 -13	8 - 22	9 - 35
13 Year Olds							
Mean	32.64	36.91	18.23	48.50	9.27	16.09	21.36
Std Dev	12.63	3.93	8.68	8.03	2.25	2.51	6.82
Range	8 - 53	32 - 44	2 - 30	29 - 60	5 - 14	10 - 20	10 - 35
14 Year Olds							
Mean	27.89	35.11	20.28	42.50	9.39	16.00	17.22
Std Dev	7.44	4.35	7.67	6.74	2.20	2.79	3.67
Range	13 - 40	26 - 44	5 - 32	34 - 56	5 - 14	9 – 20	12 - 24
15 Year Olds							
Mean	39.00	37.00	24.32	50.00	10.74	16.77	23.79
Std Dev	8.15	4.53	6.73	5.42	1.85	2.59	6.67
Range	28 - 56	28 - 43	13 - 32	40 - 59	8 - 14	12 - 22	14 - 37

LM = Logical Memory, Faces = Face Recognition, VPA = Verbal Paired Associates, Fam Pic = Family Pictures, Let Num = Letter-Number Sequencing, Spat Span = Spatial Span, Aud Rec = Auditory Recognition.

Table 2.4 (continued)

	Faces II	VPA II	Fam Pic II	Aud Rec	Digit Span
12 Year Olds					
Mean	36.60	6.10	47.37	47.30	13.45
Std Dev	3.22	2.00	8.62	4.22	2.70
Range	32 - 44	2 - 8	31 - 60	38 - 54	9 - 19
13 Year Olds					
Mean	36.59	5.91	49.00	49.46	14.09
Std Dev	5.36	2.43	7.70	2.13	2.51
Range	29 - 48	1 - 8	31 - 59	45 - 53	10 - 21
14 Year Olds					
Mean	36.56	6.39	44.89	46.89	13.94
Std Dev	4.46	2.25	6.50	3.39	2.86
Range	29 - 45	2 - 8	32 - 57	39 - 52	10 - 21
15 Year Olds					
Mean	36.16	7.32	50.84	49.21	16.26
Std Dev	4.30	1.16	5.35	2.76	2.94
Range	27 - 43	4 - 8	42 - 60	44 - 54	11 – 22

LM = Logical Memory, Faces = Face Recognition, VPA = Verbal Paired Associates, Fam Pic = Family Pictures, Let Num = Letter-Number Sequencing, Spat Span = Spatial Span, Aud Rec = Auditory Recognition.

In addition to collecting normative estimates, a one-way ANOVA was carried out for each subtest using the raw scores to determine if there was a main effect for age. A main effect for age was found for Digit Span (F (3, 77), p <. 01, with the 12-year-olds and 13-year-olds performing significantly below the 15-year-olds, and Logical Memory II (F (3,77.), p <.05 where the only significant difference was noted between the 14- and 15-year-olds.

2.4 Discussion

Normative estimates were calculated for New Zealand adolescents aged 12 to 15 years on the *WMS-III* to establish the appropriateness of the test to assess adolescents with TBI presented in chapter 3. Adolescents under the age of 16 years were able to perform the test and it was judged to be a useful measure of memory for children aged 12 years and over.

The *WMS-III* is a commonly used clinical measure and its practicality in a New Zealand setting will be enhanced with the expanded normative information. Clinicians have reported using the *WMS-III* for children under the age of 16 and relying on extrapolated scores. For research purposes, the addition of normative data across adolescence is useful for a variety of reasons. Researchers studying memory in adolescents will be able to use one measure across the age groups. In addition, studies that measure changes in performance over time will be more reliable if one measure can be used. When different measures are used it is difficult to determine whether discrepancy in performance was related to a more difficult measurement or whether an actual change occurred.

Changes in memory, particularly working memory were of interest in this study. Failure to show a change in development in working memory may have been due to the nature of the task used to assess working memory. Swanson (1996) investigated age-related differences in working memory in children aged 7, 10, and 13 years. They found that older children did have greater storage and concurrent processing abilities than younger children.

The sensitivity of the task to those developmental changes depended on how demanding the working memory task was however. They found that conditions that had higher storage loads and therefore were more demanding were more sensitive to age-related differences. In order to study age-related differences, future studies will require large sample sizes and a variety of working memory tasks. A comparison of the sensitivity of working memory tasks to age-related differences will be useful in determining how to measure working memory capacity.

At present, the normative estimates calculated for adolescents aged 12 to 15 years will provide a useful tool for studying adolescents with a variety of neuropsychological and linguistic impairments including TBI. In the study reported in Chapter 3, the *WMS-III* is administered to adolescents who are aged 12 to 16, in order to explore the relationship between working memory and language in TBI.

CHAPTER 3: LANGUAGE AND MEMORY PROFILES OF ADOLESCENTS WITH TBI

3.0 Introduction

It is well established in the literature that spoken language continues to develop in late childhood and through the adolescent years. Although not as remarkable as the growth in early childhood, significant growth in both receptive and expressive language development is evident during adolescence (Nippold, 1998;. Hypotheses of how traumatic brain injury affects developing language skills suggest that children who suffered head injuries prior to adolescence will struggle with advanced language development. Yet, profiles of adolescents' spoken language skills following brain injury during childhood have not previously been documented. In particular there is a paucity of research related to comprehension deficits that adolescence with TBI may exhibit.

Performance on listening comprehension tasks is particularly important to examine in adolescents with TBI. Listening comprehension is vital for an adolescent's success in society with listening being the most frequently used communication skill in academic, social, and occupational situations (Hartley, 1995). In secondary school, listening comprises over 60 % of a student's time in class (Lazar et al., 1987). Further, listening comprehension is related to written language comprehension, particularly during later stages of reading development when written text increases in complexity (Hoover & Gough, 1990). Despite its importance, only a few studies have examined listening comprehension abilities in adolescents with TBI (e.g. Docking et al., 1999, 2000; Turkstra & Holland, 1998). In these studies, only one aspect of listening comprehension (e.g., humour) was explored. There is a need, then, to evaluate profiles of performance across different types of listening tasks for adolescents who have suffered a TBI during childhood.

In order to explore listening comprehension profiles, analysis of individual performance may be more informative than group evaluation. At a group level, it has been demonstrated that children and adolescents who have suffered a severe traumatic brain injury display language deficits. The particular pattern of these deficits for individuals within the group, however, is largely unknown. Further, group studies of both adults and children with TBI typically include participants whom vary widely in terms of variables such as severity of the brain injury, age at injury, and time lapsed since injury. Individual differences across participants such as pre-morbid language and academic skills may also affect group results. Large sample sizes can control for such variability amongst subjects but studies with large populations of people with TBI are rare.

Descriptions of individual participants with TBI are important as they allow for the identification and discussion of how differing variables may influence an individual's language performance (Docking et al., 2000; Jordan, Murdoch, & Buttsworth, 1991; Turkstra, McDonald, & Kaufmann, 1995). Docking et al. (1999) examined comprehension of linguistic humour in nine adolescents with head injury on a case-by-case basis. Docking et al. (1999) highlighted the need to evaluate individual performance when examining language because of the heterogeneity of individuals with TBI and the extensive variability across participants, resulting from differences in age at injury, site of lesion, and severity of injury.

When evaluating the language comprehension profiles of adolescents a variety of factors must be considered. First, the tests used to measure adolescents' language need to be age-appropriate and target advanced language skills that are known to develop during the adolescence period. If the 'rapid development' hypothesis of the effects of TBI on language development is to be considered, then testing developing language processes is essential. Related to the use of developmentally appropriate tests is the necessity to use tests that target high-level language skills such as inference comprehension and figurative language. Studies examining language impairment following TBI, have offered support for a "high-level language" hypothesis to explain the deficits in TBI. Hence, it is important to use tests such as the *Test of Language Competence-Expanded (TLC-E)* (Wiig & Secord, 1989) that examine high-level language functions.

Given the relationship between working memory and comprehension (Just & Carpenter, 1992), the working memory demands of tests utilized in assessment of adolescents with TBI should also be evaluated (Turkstra & Holland, 1998). Working memory impairment has been identified in individuals with TBI (Hartley, 1995; Turksra & Holland, 1998). Turkstra & Holland (1998) found that when working memory demands were decreased, adolescents with TBI had improved performance on a sentence comprehension task. It is difficult to determine the working memory demands of standardised tests without manipulating the processing and storage variables; however the influence of working memory on test performance can be estimated.) Working memory has been shown to be associated with listening comprehension in individuals with and without brain damage (Just & Carpenter, 1992). In addition, manipulation of variables within a task has been shown to constrain working memory, affecting comprehension (King & Just, 1991; MacDonald et al., 1992). Recognition of the working memory demands of the tasks used to assess language may provide insight into the nature of language comprehension deficits in TBI. The primary aim of the study reported in this chapter was to examine the individual language comprehension profiles of adolescents who suffered TBI during childhood, using developmentally appropriate, standardised language tests. Although there are limitations with standardised tests, they form the basis of clinical identification of language impairment. It is also important to ascertain the usefulness of standardised tests in identifying language comprehension deficits for adolescents with TBI. Given the impact listening comprehension deficits are likely to have on functioning in a school environment, academic performance of the participants was also considered.

The literature supports a relationship between working memory and listening comprehension in individuals with and without brain damage. A secondary aim of the study therefore was to look at the memory profiles of adolescents with TBI and to evaluate the contribution of working memory to performance on the linguistic tasks administered. . In order to accomplish the aims set out in this study, adolescents with TBI were compared to a group of age-matched controls. In addition, individual data for each participant with TBI was examined in relation to their own performance on tasks with variable working memory demands so that influence of working memory on test performance could be explored for the test population.

3.1 Method

3.1.1 Participants

Six adolescents with traumatic brain injury and six age-matched controls were in the participant group. Participants ranged in age from 12 years 0 months to 17 years 1 month. All participants had sustained their head injury prior to age 10. The TBI group consisted of three males and three females. Biographical details of the participants are presented in Table 3.1.

Table 3:1 *Biographical Details of Subjects with Head Injuries*

Partic	Sex	Age	Age at Time of Injury	GCS	CT	Nature of Accident
1	F	14	16 mths	N/A	L & R frontal lobe; L fronto-parietal	MVA
2	F	14	10 yrs	4	Diffuse	MVA
3	F	12	8yrs	N/A	N/A	MVA
4	M	12	5yrs	7	N/A	Cyclist – MVA
5	M	17	~	N/A	Clear	MVA
6	M	16	5yrs	7	N/A	Pedestrian-MVA

GCS = Glasgow Coma Scale; CT = Computerised Tomography; MVA = Motor Vehicle Accident; N/A = Not Available; L = Left; R = Right

3.1.2 Participant Recruitment

Participants were recruited from schools in main and secondary urban regions in New Zealand. Speech-language therapists, occupational therapists, psychologists and teachers were contacted by the researcher and asked to refer adolescents with head injury who would be interested in participating in the study. In addition, an advertisement for the study was placed in the Head Injury Society Newsletter and in two urban newspapers. Participants were excluded if they had identified emotional or behavioural disorders; uncorrected sensory deficits; or motor deficits that would interfere with their ability to perform the assessment tasks. The participants selected as matched controls for the students with TBI were selected through teachers' referrals. Teachers were asked to recommend individuals who did not demonstrate academic or language difficulties and who were average students academically. Four of the six control participants were selected from the same school and classroom as the participants with TBI. In the two instances where this was not possible, the age-matched control participants were selected from schools with equivalent socioeconomic rankings determined by the New Zealand Ministry of Education. Such matching ensured similar socioeconomic status and educational backgrounds.

3.1.3 Materials

Language Tests

A battery of language tests was administered to each subject. Tests were selected to assess the areas of language that develop throughout adolescence. Measures of syntax, semantics, figurative language, inference and discourse comprehension were included. As it would be prohibitive to the participants to administer a large battery of tests in their entirety, specific subtests were selected. See Table 3.2 for a description of the subtests.

Test Description

Test of Adolescent Language (3rd Edition)

Two subtests of the *TOAL-3* (Hammill et al., 1994) were administered: Listening Grammar and Listening Vocabulary. The Listening Grammar subtest of the *TOAL-3* was administered to assess comprehension of syntax. The subtest was chosen as the *TOAL-3* is one of a few tests that was developed using the research on syntax development in adolescence (Nippold, 1998). Examinees listen to three sentence triplets. Within each triplet, two sentences are comparable in meaning, whereas a third sentence has a different meaning. An example of a stimulus item is as follows:

A. Do not begin until the signal sounds.

B. The signal will not sound until you begin.

C. Wait for the signal before you begin.

All stimuli were read aloud to the participant according to the directions given in the test manual. The task was administered and scored according to the subtest protocol. Sentences ranged from 3 to 16 words and there were no significant differences between the similar and dissimilar sentences (Turkstra & Holland, 1998).

The Listening Vocabulary subtest is a unique measure of vocabulary as it evaluates understanding of words with multiple meanings. The participants listened to a word and were presented with four black and white pictures. They were required to point to two pictures that could represent the word. For instance if the word *absorbed* was presented, the participant would point to a picture of a sponge and a picture of a person engaged in an activity.

Peabody Picture Vocabulary Test (3rd Edition)

The *PPVT-III* (Dunn & Dunn, 1997) was administered and scored in strict accordance with the Administration Manual. The *PPVT-III* tests vocabulary by having the examinee listen to a word and then point to one of four black and white drawings. A new set of four pictures was presented for each stimulus item. The *PPVT-III* was included as it is a standard measure of vocabulary and was identified as one of the most commonly used tests in the United States for assessing children with TBI (Frank, Williams, & Butler, 1997).

Test of Language Competence-Expanded

Two subtests of the *TLC-E* (Wiig & Secord, 1989) Level 2 were administered. The first subtest was the Listening Comprehension: Making Inferences subtest. This subtest evaluates a person's ability to identify plausible inferences based on information heard in short stories. Participants listened to two sentences in which one or more causal links were missing. For example: "*The sun was shining when the Robertsons started out for the picnic.*

Unfortunately, they had to have the picnic in the living room." In this example, the participant determines what might have happened in the middle (i.e. what caused the family to stay home). All the stories contained two propositions: one that served as a lead-in and one that served as a conclusion (Wiig & Secord, 1989). The sentences were read aloud and then presented in writing to the adolescents. The participants read and heard four possible inferences from which they had to identify two plausible choices. For the example given above, the possible interpretations were:

The Robertsons had the picnic in the living room because:

a. They didn't like to eat at a picnic table.

b. Their car broke down and had to be fixed.

c. It was a beautiful sunny day.

d. It rained heavily all afternoon.

Sixteen short paragraphs were presented to each participant. All items were administered. Subjects received a score of 1 if they identified one plausible inference and a score of 3 if they identified two plausible inferences.

The second subtest administered from the *TLC*-E was the Figurative Language subtest. This subtest was designed to evaluate understanding of metaphors and idioms. Twelve items, each a commonly used idiom or expression, were presented. The participants heard and read the expression and explained the meaning to the examiner. The participants were then asked to match the expression with another figurative expression. For example:

Situation: Two boys talking at a dog show

Expression: He is crazy about that pet.

Response: Student matches on of the items with the expression:

a) The pet makes him angry.

b) He is up in arms about the pet.

c) The pet is really wild.

d) He is really wild about the pet.

Participants received a score of 1 if they were able to either explain the expression or match the figurative expression correctly. A score of 3 was received if participants could do both.

Clinical Evaluation of Language Fundamentals (3rd Edition)

The Listening to Paragraphs supplementary subtest from the *CELF-3* (Semel, Wiig, & Secord, 1995) was administered to evaluate understanding of discourse. The task has been standardised for adolescents up to the age of 21. The subtest is a supplementary subtest of the *CELF-3*. The subtest is made up of two paragraphs that have been controlled for grade-level listening skills. The paragraphs were read aloud by the examiner and the participants were required to listen and answer questions. After listening to each paragraph subjects were asked five questions about the paragraph. The question types all targeted different aspects of the paragraph. The aspects covered by the questions were: details, main idea, prediction, inference, and sequence. A score of 1 was given for each question answered correctly. The total raw score was the sum of all correctly answered questions.

Rankings of Tests by Working Memory Load

Selected subtests were ranked on a scale of 1 to 6, according to the working memory demands of the task. The ranking was based on procedures suggested by Turkstra (1999). Scores of 1 and 2 reflected low working memory demands. Scores of 3 and 4 reflected medium working memory demands and scores of 5 and 6 reflected high working memory demands. Storage and processing loads were estimated to derive an overall ranking: Storage demands were evaluated based on how much information had to be stored whereas processing demands were determined by the number of mental operations that needed to be performed in the task. The rankings were consistent with research findings related to the working memory demands of particular tasks. The rankings were made, prior to administration of the tests. The rankings as well as rationale for the rankings can be found in Table 3.2.

Table 3.2 Rankings of Tests by Working Memory Load

	Subtest	WM Rank	Rationale of Ranking
Test of Adolescent Language (3rd Edition) (TOAL-3, Hammill, Brown, Larsen, & Wiederholt, 1994)	Listening to Sentences subtest (Syntax)	6	Requires a large number of items to be retained (storage) and compared (processing). Syntax is complex.
Peabody Picture Vocabulary Test- III (PPVT-III, Dunn & Dunn, 1997)	Form A (Receptive Vocabulary)	2	Requires only one item to be stored; item has to be retrieved from long term memory (processing) and compared to four pictured items.
Test of Language Competence-Expanded (TLC-E, Wiig & Secord, 1989)	Listening Comprehension: Making Inferences subtest	5	A large number of items have to be held and compared.
Test of Language Competence-Expanded (TLC-E, Wiig & Secord, 1989)	Figurative Language subtest	4	Comprehension of idiomatic expressions may involve analysis of the lexical items in the sentence, which is likely to involve working memory. Working memory demands would be reduced however if test items were familiar.

Clinical Evaluation of Language Fundamentals-Third Edition (CELF-3, Semel, Wiig, & Secord, 1995)	Listening to Paragraphs subtest (Discourse Comprehension)	6	Story needs to be retained while questions are listened to, comprehended and evaluated. Some questions require inferencing.
Test of Adolescent Language (3rd Edition) (TOAL-3, Hammill, Brown, Larsen, & Wiederholt,1994)	Understanding of Multiple Meanings	3	Working memory would be involved in storing both possible meanings and comparing the items to the pictured concepts.

(WM rank = Working Memory Ranking)

Memory Measures

The *Wechsler Memory Scale-III* (Wechsler, 1997) was administered in order to assess working memory as well as other types of memory. The *WMS-III* was described fully in Chapter 2. The verbal memory measures and the Working Memory Index of the *WMS-III* were of particular interest in this study.

The Working Memory Index is of interest as a relationship between listening comprehension and working memory would be predicted, particularly for tasks that have high storage and/or processing demands. Wechsler (1997) examined the relationship between the *WMS-III* measures and specific language tasks and spatial processing tasks. The Working Memory Index was more highly correlated with the spatial processing tasks than the language tasks. It is possible, however that the verbal working memory task, Letter-Number Sequencing, may be more highly associated with language comprehension than the visual-spatial working memory task. It has been argued that working memory is a unitary construct and therefore tasks other than verbal processing tasks can measure working memory (Turner & Engle, 1989). However the tasks used to test the hypothesis (e.g. Turner

& Engle's (1989) operation span task) have a verbal component to them. In addition, the Spatial Span task appears to be more a measure of storage alone versus storage and processing. Although it is intended to measure " the examinee's ability to hold a visual-spatial sequence of events in memory" (Wechsler, 1997, p.204), the existence of an actual processing component is questionable.

The relationship between additional verbal memory measures; Logical Memory I and II, Verbal Paired Associates I and II, and Digit Span, and language comprehension measures were of interest. The Logical Memory subtests would be predicted to be related to the Understanding Paragraphs subtest of the *CELF-3*, as the tasks have similar listening demands and memory requirements. It has also been noted that story retelling tasks such as the Logical Memory Tasks, can also be considered measures of working memory (Swanson, 1992). If working memory is related to auditory comprehension, and story recall taps working memory, then scores on story retell tasks would likely be correlated with auditory comprehension. The relationship between the Verbal Paired Associate tasks and language comprehension is more difficult to predict. Performance on the VPAI is thought to be indicative of learning ability and memory for auditory information (Wechsler, 1997). The VPAI was slightly correlated with Letter-Number Sequencing but not with any other subtest of the *WMS-III* (except for VPAII). A low correlation between VPAI and auditory comprehension could be predicted.

3.1.4 Procedures

Participants were assessed individually in a quiet room at their school or at home. The order of administration of subtests was varied to avoid order effects. Tasks were administered to participants in the control group in the same order received by the participant with TBI. The investigator administered all tests. The testing session was recorded using a

Sony TCM – 5000EV cassette recorder. The testing session lasted between 2 and 2 ½ hours. Students were offered breaks at the completion of subtests. Juice and biscuits were available for the participants throughout the session. Participants who were assessed in the morning in their school environment also had a 15-minute interval break. Information regarding adolescents' injury details and academic performance was collected from medical and school files and parental report.

3.2 Analysis: Case Reports

The background and test performance of each individual is presented followed by a discussion of the individual's performance profiles.

3.2.1 Case Study 1 (AR)

Background

AR is a 14-year-old female attending a secondary school in a high socioeconomic area (Decile ranking 9) in a secondary urban center in New Zealand. At the age of 16 months, AR, sustained a head-injury while a passenger in a motor vehicle accident, resulting in damage to the left and right frontal lobe and to the left frontoparietal region. A Glasgow Coma Scale score was not recorded, nor was there mention of a period of unconsciousness. The injury was recorded in the medical files as "severe". Prior to the injury, AR's development was reported by her mother to be normal. AR has received speech-language therapy at school on a weekly basis for the past three years and continues to receive treatment. She had received some speech and language therapy services when she first started school, however treatment sessions were inconsistent. She also receives physiotherapy, which focuses on general muscle strengthening; and occupational therapy, which focuses on organization and life skills such as cooking. Academically, AR is on and Individualised Education Program (IEP). The program focuses on adapting school subjects such as English, Science, Mathematics and Social Studies to AR's needs. Issues identified in the IEP include the need for teachers to provide direct instruction, minimize inference requirements, and alert AR to topic changes. AR was reported to have reading and writing difficulties.

The participant who served as a control was also 14 years of age and was in the same classroom as AR. She was described as a student of average ability.

Results

Language Tests

AR's scores were below average on all language subtests administered except for the Understanding Paragraphs subtest of the *CELF-3*. A profile of the language test scores is depicted in Figure 3.1. AR demonstrated an overall receptive vocabulary deficit as demonstrated by her score on the *PPVT-III* (4^{th} percentile) and the Listening Vocabulary subtest of the *TOAL-3* (5^{th} percentile). Syntax comprehension was higher (9^{th} percentile). The higher-level language skills of inference comprehension and figurative language comprehension were profoundly impaired (1^{st} and 2^{nd} percentile respectively). Discourse comprehension was a relative strength for AR who scored at the 16^{th} percentile. Evaluations of AR's responses on the Listening to Paragraphs subtest of the *CELF-3*demonstrated an ability to appropriately answer both inferential and non-inferential questions.

The participant who served as the age-matched control obtained scores that were within average for all subtests as depicted in Figure 3.1. The control participant achieved higher scores than AR on all subtests except for the Discourse Comprehension subtest, where they achieved identical scores.

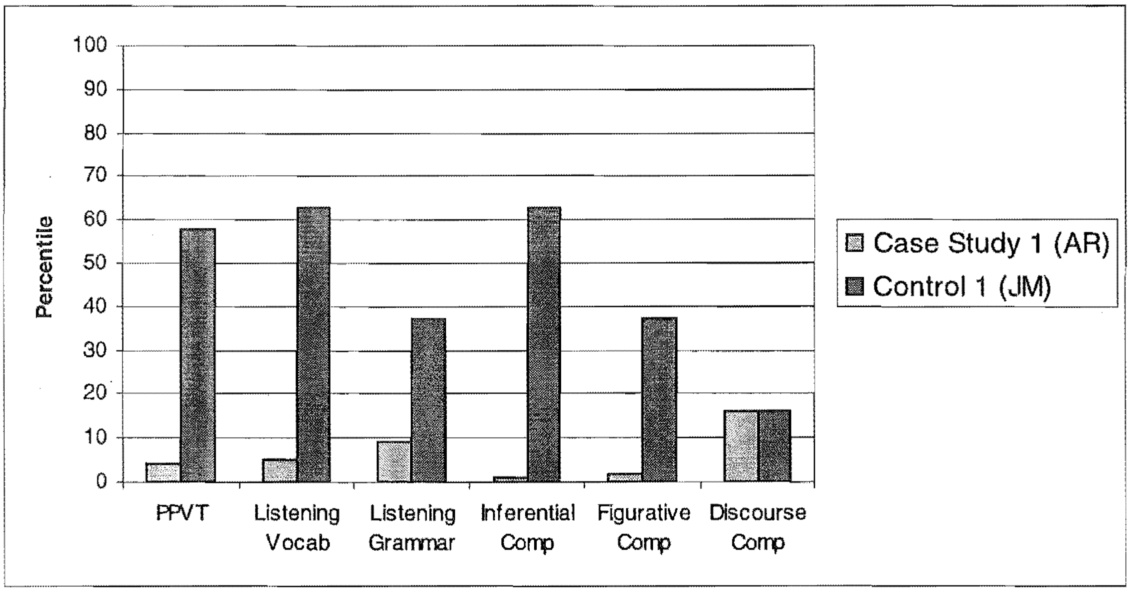

Figure 3.1. *Percentile scores for Participant 1 and an age-matched control participant on a battery of listening comprehension tasks. PPVT = Peabody Picture Vocabulary Test (Dunn & Dunn, 1997); Listening Vocab = Listening Vocabulary Subtest of the Test of Adolescent Language-Third Edition (Hammill, Brown, Larsen, & Wiederholt, 1994); Listening Grammar = Listening Grammar subtest of the Test of Adolescent Language-Third Edition; Inferential Comp = Listening Comprehension: Making Inferences subtest of the Test of Language Competence-Expanded (Wiig & Secord, 1989); Figurative Comp = Figurative Language subtest of the Test of Language Competence-Expanded; Discourse Comp = Listening to Paragraphs subtest of the Clinical Evaluation of Language Fundamentals-Third Edition (Semel, Wiig, & Secord, 1995).*

Memory Tests

AR's scores on the *WMS-III* were below average when compared to the normative estimates obtained for 14-year-old adolescents. Scores that were of particular interest were the Letter-Number Sequencing Score, which is designed to target working memory and the

Digit Span score. AR scored below the 1st percentile on the Letter-Number Sequencing task. Digit Span was at the 2nd percentile. Spatial span, which is the non-verbal equivalent of Digit Span, was at the 16th percentile. AR scored below the 1st percentile on Verbal Paired Associates I and II. Figure 3.2 outlines verbal memory and working memory scores for RH and an age-matched control participant.

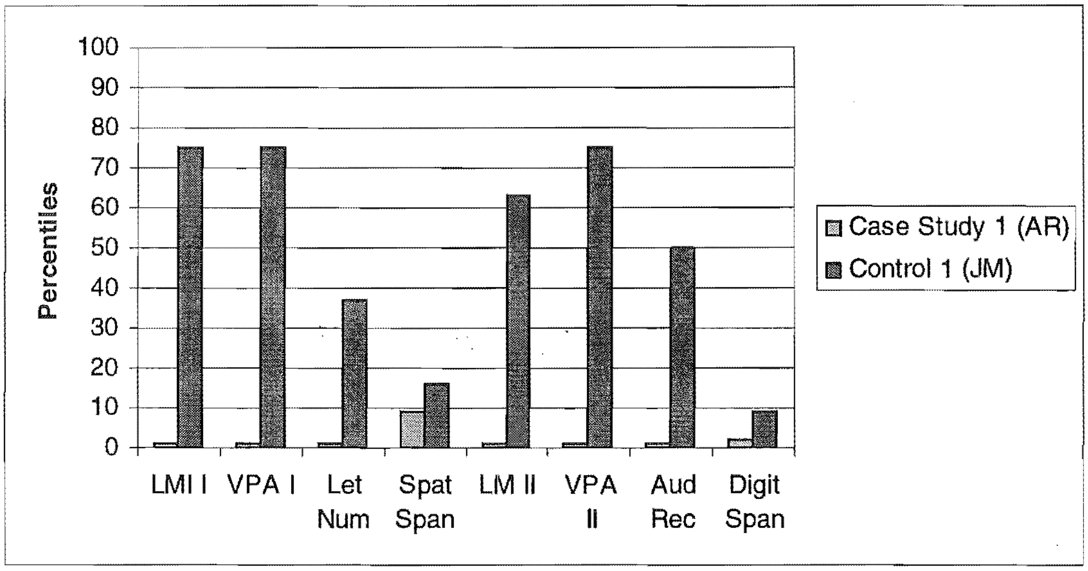

Figure 3.2. Percentile scores for Participant 1 and an age-matched control on subtests of the Wechsler Memory Scale- Third Edition (Wechsler, 1997). LM = Logical Memory, VPA = Verbal Paired Associates; Let Num = Letter-Number Sequencing; Spat Span = Spatial Span; Auditory Rec. = Auditory Recognition

Summary of Results

Comprehension deficits were clearly identifiable on the language tests administered. AR's linguistic deficits are consistent with her poor academic performance and suggest that severe TBI in infancy may have persistent and long-term effects on language development.

3.2.2 Case Study 2 (AH)

Background

A.H is a 14 -year-old female, attending a private girl's school in a major urban center in New Zealand. AH sustained a severe head injury at the age of 10 years, 10 months. She was a passenger in a motor vehicle and was projected through the windscreen of the vehicle. AH had a Glasgow Coma Scale (GCS) (Teasdale & Jennett, 1974) rating of 4 at time of admission to hospital, which was upgraded to 6, 24 hours later. Glasgow Coma Scale scores are estimates of the severity of injury based on Eye Opening, Motor Response and Verbal Response. The rating scale is from 3 to 15, with 3-8 considered severe, 9-12 considered moderate, and 13-15 considered mild. Unfortunately there are problems with the GCS ratings for young children, particularly children who are preverbal. She was on life-support systems and a coma was induced. She remained unconscious for 21 days. AH has never received speech and language therapy. She is however under ongoing monitoring by an occupational therapist to improve her organizational abilities. AH receives teacher-assistant support in school for 5 hours per week for assistance in organizing homework and ensuring books are taken home from school. Prior to her injury AH was assessed by an educational psychologist and identified as gifted. Her mother reports that AH now has difficulty with academic tasks such as written formulation, retaining information and has poor organizational ability. She also needs to re-read material several times to ensure accurate comprehension. Her performance at school is considered by her teachers to be in the average range but maintenance of this performance requires intensive effort.. Following the brain injury AH has experienced considerable and persistent fatigue

The matched control participant was selected from the same private girls school that AH attended. She was 14 years, 0 months at the time of assessment and was in Year 10. She was described as a bright student, although not gifted, and was in an advanced math class. It was considered appropriate to match AH with a female of high average intelligence as AH was performing above average academically prior to the accident

Results

Language Tests

AH scored at the 81st percentile on the *PPVT-III*, which is the upper end of the normal range. Her performance on the Listening Vocabulary subtest of the *TOAL-3* was within normal limits (25th percentile) but lower than her score on the *PPVT-III*. The 25th percentile is considered the low end of average. Inference and figurative language comprehension as measured by the *TLC-E* were at the 50th and 37th percentile respectively. These were considered to be within normal limits for her age. Listening grammar was also at the 50th percentile. AH scored below average on the Listening to Paragraphs subtest of the *CELF-3* (9th percentile). She had difficulty with both inferential and non-inferential questions. Considering AH's average scores on all other linguistic measures, the below average score for Listening to Paragraphs is remarkable. AH's profile is represented in Figure 3.3. The age-matched participant achieved higher scores than AH on all but the Inference Comprehension subtest, where they achieved equivalent scores.

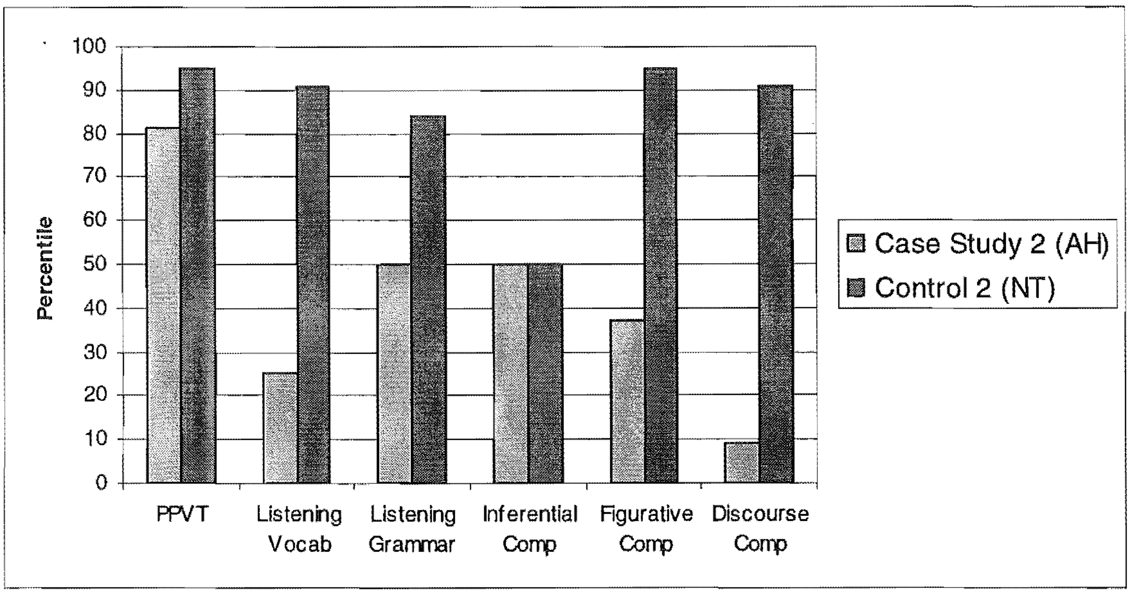

Figure 3.3. Percentile scores for Participant 2 and an age-matched control participant on a battery of listening comprehension tasks. PPVT = Peabody Picture Vocabulary Test (Dunn & Dunn, 1997); Listening Vocab = Listening Vocabulary Subtest of the Test of Adolescent Language-Third Edition (Hammill, Brown, Larsen, & Wiederholt, 1994); Listening Grammar = Listening Grammar subtest of the Test of Adolescent Language-Third Edition; Inferential Comp = Listening Comprehension: Making Inferences subtest of the Test of Language Competence-Expanded (Wiig & Secord, 1989); Figurative Comp = Figurative Language subtest of the Test of Language Competence-Expanded; Discourse Comp = Listening to Paragraphs subtest of the Clinical Evaluation of Language Fundamentals-Revised (Semel, Wiig, & Secord, 1995).

Memory Tests

AH's performance on the Letter-Number Sequencing tasks of the *WMS-III* was below normal (7th percentile). Digit span and Spatial Span were within normal limits (20th percentile and 45th percentile respectively). All other tasks were within normal limits (See Table 3.2)

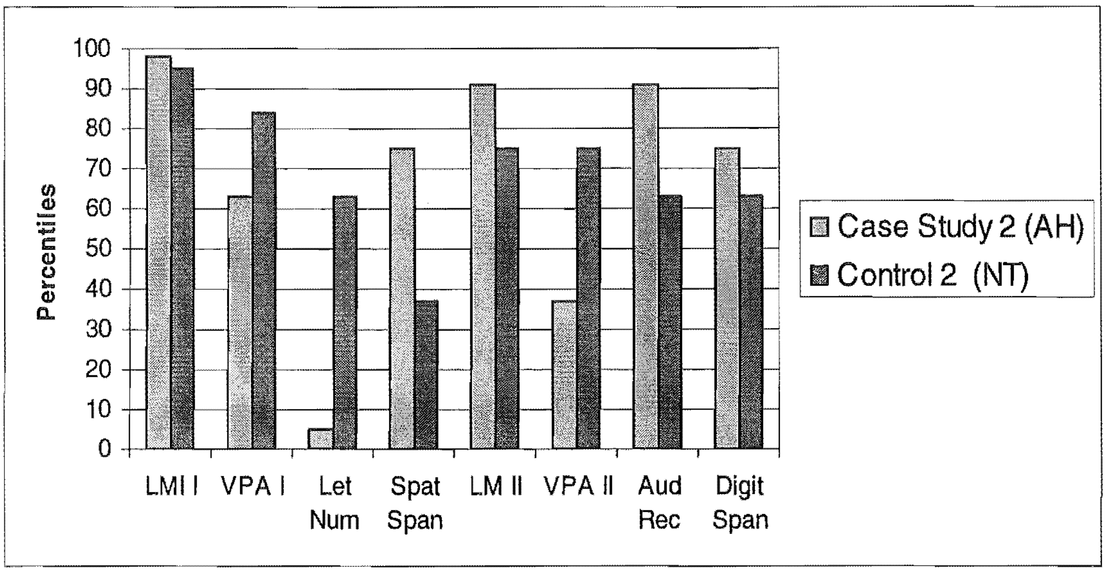

Figure 3.4. Percentile scores for Participant 2 and an age-matched control on subtests of the Wechsler Memory Scale- Third Edition (Wechsler, 1997). LM = Logical Memory, VPA = Verbal Paired Associates; Let Num = Letter-Number Sequencing; Spat Span = Spatial Span; Auditory Rec. = Auditory Recognition

Summary of Results

Without considering AH's pre- morbid condition it would appear AH's linguistic outcomes were inconsistent with literature related to language performance following severe TBI. Typically, severe TBI is associated with impaired language performance on receptive and expressive language measures (Ewing-Cobbs et al., 1987; Jordan & Murdoch, 1984). AH performed below normal on only one subtest. However, AH's linguistic profile is not what would be expected from a student with superior intellectual abilities. Given that there is documented evidence of AH's gifted intellectual abilities prior to the TBI, it is reasonable to conclude that the brain injury negatively affected AH's language development in adolescence. This assumption is supported by the discrepancies in her language scores and reports from AH and her mother reported that she experienced difficulty academically following the TBI.

3.2.3 Case Study 3 (RH)

Background

RH is a Year 8 student at a Christian school in a large urban center in a middle socioeconomic area (Decile 7). She was 12 years, 3 months at the time of assessment. RH has only attended her current school for 5 months. She was formerly a pupil at a private girl's school. RH was 8 years, 0 months at the time of her injury. She was involved in a motor vehicle accident and was projected through the windscreen of the vehicle. She sustained severe facial injuries, abrasions on the left ear and a broken left scapula. She was not immediately diagnosed as head-injured but eventually a diagnosis of mild-head injury was recorded. There was no Glasgow Coma Scale assessment and no record of a period of unconsciousness. A scan did not show any areas of lesion. RH did spend several nights in the hospital while her other injuries were addressed. Prior to the injury at 8 years of age, RH had sustained multiple concussions at 6 months, 18months, and 3 years of age as a result of various falls including falling from her high chair, and falling from a bed while playing with her sister. RH has not received speech and language therapy. Since her TBI, she has received occupational therapy to assist her with organizational difficulties. RH has recently been identified as having peripheral vision difficulties. Academically RH has difficulties with written language and mathematics. Her Progressive Achievement Test (PAT) results for 2002 were average for Listening Comprehension, Vocabulary Comprehension, and Reading Comprehension but below average for Mathematics. It was reported that she tends to interpret information literally in class and at home and has exhibited work avoidance behaviours in class. Prior to her injury, she was considered to be an average student and did not present with academic or behavioural difficulties.

The control participant was 12 years, 9 months and like RH was in a Year 8 class. She did not attend the same school as RH. Instead she was selected from a school of similar socioeconomic neighborhoods. She was reported to be average student. As RH was considered to be an average student prior to her accident, the match was deemed appropriate.

Results

Language tests

RH's profile (Figure 3.5) demonstrated that she scored within normal limits on all tasks except the Listening Vocabulary subtest of the *TOAL-3* (9^{th} percentile). Performance on the Listening Grammar subtest was also slightly lower than other subtests (25^{th} percentile). Her highest score was on the *PPVT-III* (64^{th} percentile).

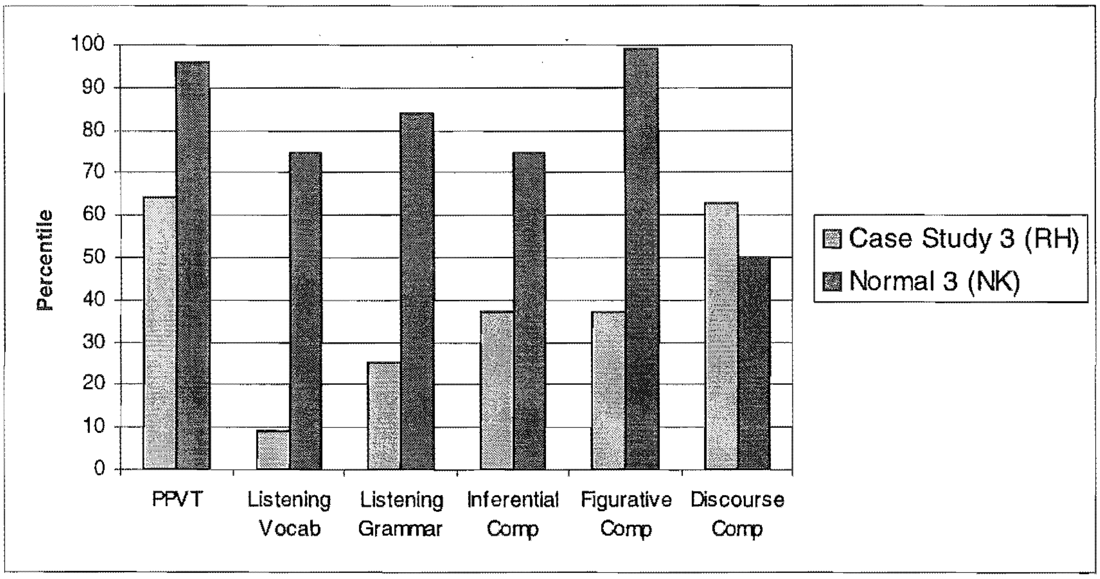

Figure 3.5. *Percentile scores for Participant 3 and an age-matched control participant on a battery of listening comprehension tasks. PPVT = Peabody Picture Vocabulary Test (Dunn & Dunn, 1997); Listening Vocab = Listening Vocabulary Subtest of the Test of Adolescent Language-Third Edition (Hammill, Brown, Larsen, & Wiederholt, 1994); Listening Grammar = Listening Grammar subtest of the Test of Adolescent Language-Third Edition; Inferential Comp = Listening Comprehension: Making Inferences subtest of the Test of Language Competence-Expanded (Wiig & Secord, 1989); Figurative Comp = Figurative*

Language subtest of the Test of Language Competence-Expanded; Discourse Comp = Listening to Paragraphs subtest of the Clinical Evaluation of Fundamentals-Third Edition (Semel, Wiig, & Secord, 1995).

Memory Tests

RH scored significantly below average on the Digit Span subtest, which measures storage, and the working memory measure subtest, Letter-Number Sequencing. Other memory measures were within normal limits. RH's performance on the Logical Memory subtest however, was remarkable. The Logical Memory subtest involves listening to a story and then telling it back. RH remembered most aspects of the first story. On the second story she was unable to recall any details but with a repetition of this story she was able to recall some details. The scores for RH and an age-matched participant are reported in Figure 3.6.

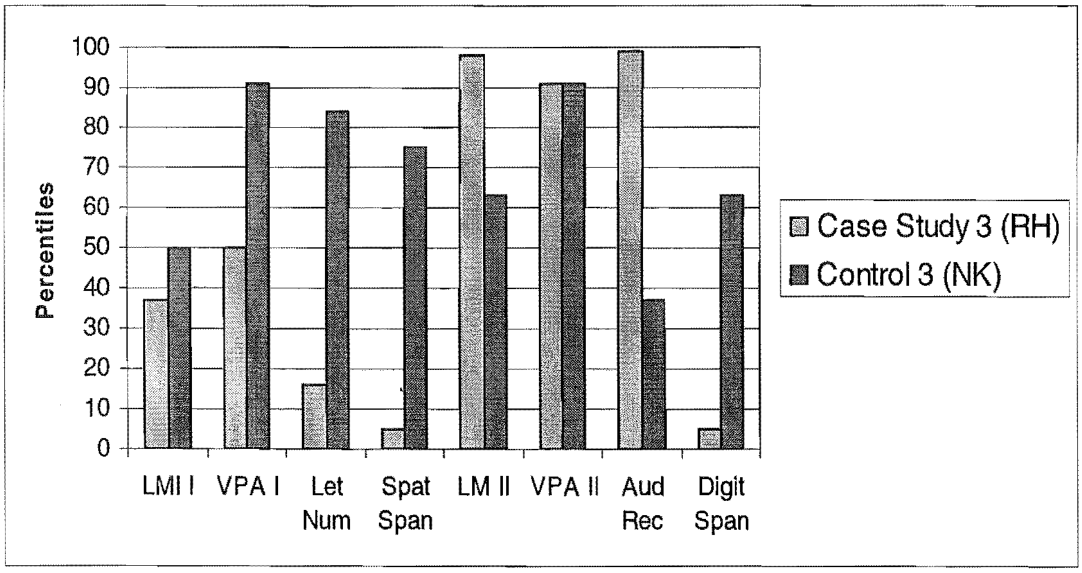

Figure 3.6. *Percentile scores for participant 3 and an age-matched control on subtests of the Wechsler Memory Scale- Third Edition (Wechsler, 1997). LM = Logical Memory, VPA = Verbal Paired Associates; Let Num = Letter-Number Sequencing; Spat Span = Spatial Span; Auditory Rec. = Auditory Recognition*

Summary of Results

RH, a 12-year-old female with mild head-injury, presented with below average working memory scores and poor comprehension of multiple meanings. Despite obtaining average comprehension skills on most areas of testing, she presented with academic difficulties in the areas of written language and mathematics. In addition, difficulties with following instructions at home and at school were reported. These difficulties were considered by her teachers to be sufficient to warrant an Individual Education Plan (IEP).

3.2.4 Case Study 4 (CV)

Background

CV was 12 years, 0 months at the time of assessment. He was in a Year 8 class at a secondary school in a high socioeconomic area in a secondary urban center in New Zealand. He sustained a severe head injury (Glasgow Coma Scale of 7) at 5 years of age when he was struck by a car while riding his bicycle. Additional injuries sustained included bilateral cranial nerve VI palsies, mild pulmonary contusions bilaterally and compound fractures of the right tibia and fibula. A speech-language therapist has been working with CV for approximately 3 years. He also receives intervention from an occupational therapist and a physiotherapist. Academically, CV has difficulties with written language and mathematics.

The age-matched control participant was also 12 years, 0 months at the time of testing. He was selected from CV's class and was described as an average student.

Results

Language Tests

A profile of CV's auditory comprehension skills, as measured by various standardised tests is depicted in Figure 3.7. CV scored below average on the *PPVT-III* (9^{th}

percentile). Scores were lower for additional areas of language comprehension including understanding of words with multiple meanings, inference comprehension, figurative language comprehension, and understanding paragraphs. Contrastively, CV scored significantly better on the Listening Grammar subtest of the *TOAL-III* (63rd percentile). Overall, language comprehension was impaired compared to the standardization sample and the age-matched control on all but the Listening Grammar subtest where CV performed better than the control participant.

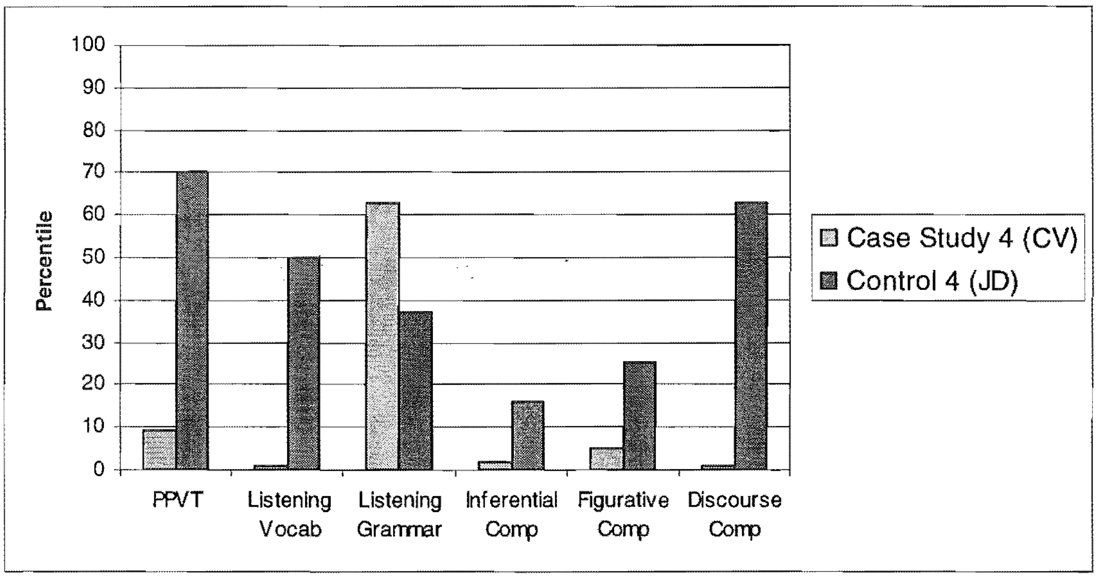

Figure 3.7. *Percentile scores for Participant 4 and an age-matched control participant on a battery of listening comprehension tasks. PPVT = Peabody Picture Vocabulary Test (Dunn & Dunn, 1997); Listening Vocab = Listening Vocabulary Subtest of the Test of Adolescent Language-Third Edition (Hammill, Brown, Larsen, & Wiederholt, 1994); Listening Grammar = Listening Grammar subtest of the Test of Adolescent Language-Third Edition; Inferential Comp = Listening Comprehension: Making Inferences subtest of the Test of Language Competence-Expanded (Wiig & Secord, 1989); Figurative Comp = Figurative Language subtest of the Test of Language Competence-Expanded; Discourse Comp = Listening to Paragraphs subtest of the Clinical Evaluation of Language Fundamentals-Revised (Semel, Wiig, & Secord, 1995).*

Memory Tests

Figure3.8 outlines the scores for CV and an age-matched control participant. CV achieved average scores on all subtests of the *WMS-III* with the exception of the Verbal Paired Associates I and II (VPA). For the VPAI subtest, the student listens to lists of word pairs. The examiner reads out the first word of the pair and the examinee recalls the second word. The list is repeated four times and the total number of words recalled is calculated. CV could not retain more than two word pairs out of eight, even following several repetitions. CV's working memory score and storage score (i.e. Digit Span) were within normal limits.

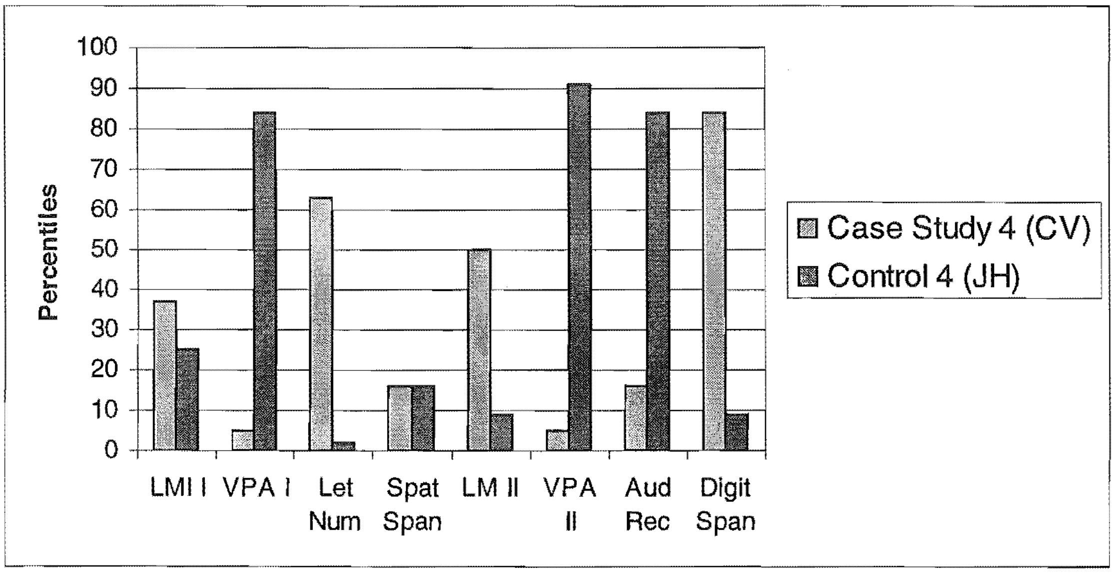

Figure 3.8. *Percentile scores for Participant 4 and an age-matched control on subtests of the Wechsler Memory Scale- Third Edition (Wechsler, 1997). LM = Logical Memory, VPA = Verbal Paired Associates; Let Num = Letter-Number Sequencing; Spat Span = Spatial Span; Auditory Rec. = Auditory Recognition*

Summary of Results

CV presented with receptive language impairments in all areas except syntax. The working memory score was average for his age. CV's impairments are reflected in his academic performance.

3.2.5 Case Study 5 (JW)

Background

JW was 16 years, 9 months at the time of testing. JW was in Year 12 at a secondary school in a large urban city. JW sustained a mild head injury at 3 years of age when involved in a motor vehicle accident. He sustained severe abdominal injuries and had partial hearing loss in the left ear (hearing in the right ear is normal). His development prior to injury was considered normal as evidenced by caregiver reports. A CT scan performed at the time of injury and did not show any brain damage but the medical team diagnosed a head injury after JW commenced school. This diagnosis was supported by evidence of slowed performance, and academic difficulties. In order to maintain acceptable academic standards throughout his school years, JW required extensive help at home. No remedial help was offered at primary school where JW was described as "slow and lazy". At the time of assessment, JW was succeeding in school in the areas of accounting, math, and science. He has omitted English from his curriculum however, on the recommendation of a neuropsychologist, due to his underachievement in this area. JW's primary caregiver reported that JW had persistent difficulties with understanding direction, and frequently only interpreted literal meaning of spoken information. His caregiver also reported social difficulties but JW did not perceive that he had any difficulty in a social context.

An age-matched control participant was selected from JW's Accounting Class at school based on the teacher's assessment that the two boys' performance in the subject area was comparable.

Language Tests

JW scored within the average or above average range on all comprehension subtests however there were discrepancies across some scores (See figure3.9). JW scored at the 97th percentile on the *PPVT-III*, which is above average for his age. He was at the 84th percentile for the Listening Vocabulary subtest of the *TOAL-3*. Listening Grammar, Inference Comprehension and Paragraph Understanding were at the 50th, 63rd, 63rd percentiles respectively. He scored at the 25th percentile for figurative language comprehension, which is at the low end of average. The age-matched control participant achieved scores that were similar to JW's and in for some subtests he performed more poorly. JW and the age-matched participant had similar variation in profiles.

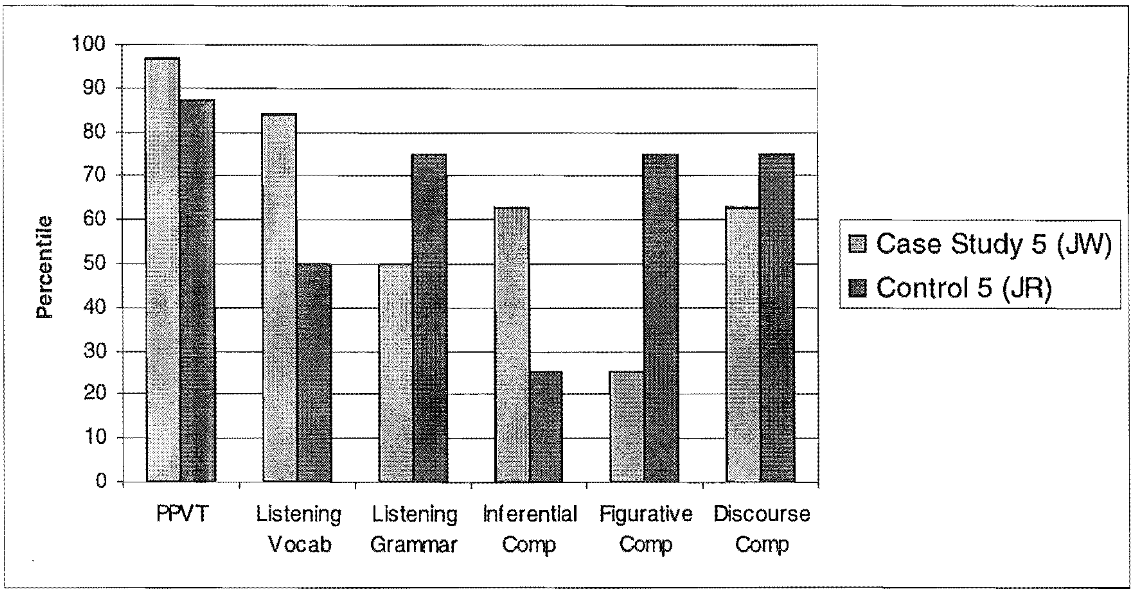

Figure 3.9. *Percentile scores for Participant 5 and an age-matched control participant on a battery of listening comprehension tasks. PPVT = Peabody Picture Vocabulary Test (Dunn & Dunn, 1997); Listening Vocab = Listening Vocabulary Subtest of the Test of Adolescent*

Language-Third Edition (Hammill, Brown, Larsen, & Wiederholt, 1994); Listening Grammar = Listening Grammar subtest of the Test of Adolescent Language-Third Edition; Inferential Comp = Listening Comprehension: Making Inferences subtest of the Test of Language Competence-Expanded (Wiig & Secord, 1989); Figurative Comp = Figurative Language subtest of the Test of Language Competence-Expanded; Discourse Comp = Listening to Paragraphs subtest of the Clinical Evaluation of Language Fundamentals-Revised (Semel, Wiig, & Secord, 1995).

Memory Tests

JW scored within average for all subtests of the *WMS-III* except for the working memory measure, Letter-Number Sequencing (9^{th} percentile). Other scores at the low end of average were Digit Span (16^{th} percentile) and Face Recognition (16^{th} percentile). JW's results, as well as the results of the age-matched control participant are reported in Figure 3.10.

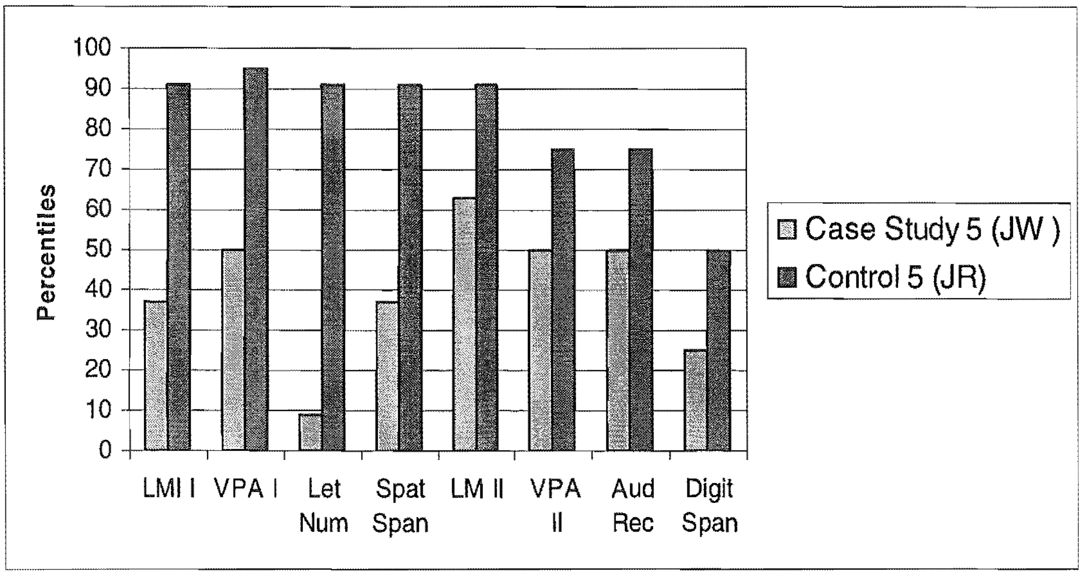

Figure 3.10. Percentile scores for Participant 5 and an age-matched control on subtests of the Wechsler Memory Scale- Third Edition (Wechsler, 1997). LM = Logical Memory, VPA = Verbal Paired Associates; Let Num = Letter-Number Sequencing; Spat Span = Spatial Span; Auditory Rec. = Auditory Recognition.

Summary of Results

JW presents with age-appropriate listening comprehension skills in spite of mixed academic performance and reported difficulties with social interaction. Working memory, as measured by one subtest, the Letter-Number Sequencing subtest of the *WMS-III* was impaired.

3.2.6 Case Study 6 (SC)

Background

SC is a 16-year-old male, who sustained a severe head injury at the age at 7 years, 6 months of age. A car struck SC as he was walking. He was in a coma for 3 days and had a Glasgow Coma Scale Rating of 6. He suffered Post Traumatic Amnesia (PTA) for approximately 3 weeks following the accident. Prior to sustaining the severe head injury, SC had sustained two previous concussions. He was concussed at 2 years of age after falling off a table, and again at 5 years of age when he fell at school. SC experienced some reading difficulties prior to his severe head injury at 7 years of age, but generally was functioning well in school. He did not receive any remedial support. Following the severe TBI, SC was unable to read and write and he stopped attending school at age 14. He was home-schooled by his parents since that time. A speech-language therapist is currently treating SC's language difficulties.

An age-matched control participant was recruited from a secondary school in SC's school zone. The participant was described performing at an average academic level.

Language Tests

A profile of SC's performance on the auditory comprehension battery is shown in Figure 3.11. SC had an above average receptive vocabulary score as measured by the *PPVT-III* (90th percentile). Considering SC's difficulties with literate material, this result is notable. His score on the Listening Vocabulary Test (25th percentile), while within normal limits, was lower than his *PPVT-III* score. Listening Grammar was within normal limits (25th percentile) as was figurative language comprehension (50th percentile). SC had significant impairment on the inference comprehension and the paragraph comprehension subtests (2nd percentile and 1st percentile, respectively). Given that SC obtained an above average score for receptive vocabulary, his low average and below average scores on the other language tests (except for figurative language comprehension) are remarkable.

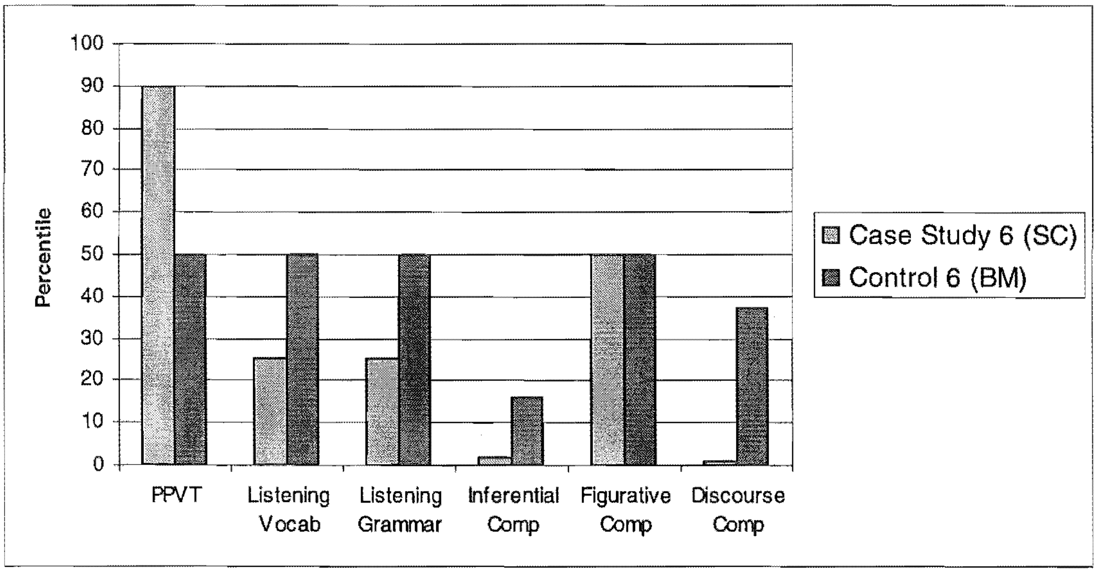

Figure 3.11. *Percentile scores for Participant 6 and an age-matched control participant on a battery of listening comprehension tasks. PPVT = Peabody Picture Vocabulary Test (Dunn & Dunn, 1997); Listening Vocab = Listening Vocabulary Subtest of the Test of*

Adolescent Language-Third Edition (Hammill, Brown, Larsen, & Wiederholt, 1994); Listening Grammar = Listening Grammar subtest of the Test of Adolescent Language-Third Edition; Inferential Comp = Listening Comprehension: Making Inferences subtest of the Test of Language Competence-Expanded (Wiig & Secord, 1989); Figurative Comp = Figurative Language subtest of the Test of Language Competence-Expanded; Discourse Comp = Listening to Paragraphs subtest of the Clinical Evaluation of Language Fundamentals-Revised (Semel, Wiig, & Secord, 1995).

Memory Tests

SC achieved low average and below average scores on all subtests of the *WMS-III* (See Table 3.2.) He scored within normal limits on the Spatial Span task and the Verbal Paired Associates I tasks but performance on VPAII was just below normal limits. Performance on Letter-Number Sequencing, Logical Memory I and II, Faces I and II, and Family Pictures I and II was also below average.

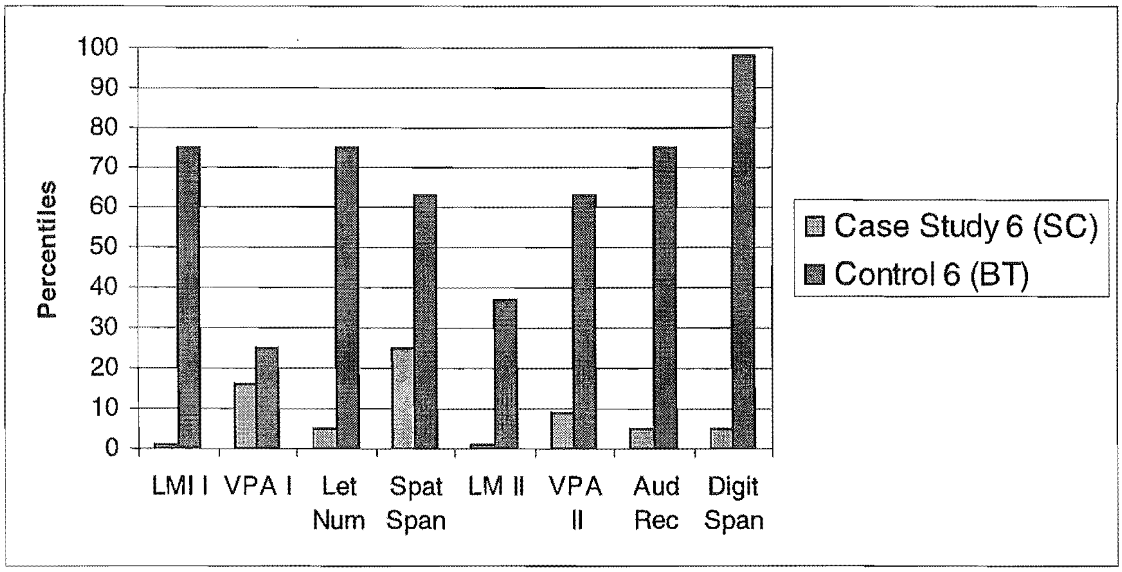

Figure 3.12. *Percentile scores for Participant 6 and an age-matched control on subtests of the Wechsler Memory Scale- Third Edition (Wechsler, 1997). LM = Logical Memory, VPA*

= *Verbal Paired Associates; Let Num = Letter-Number Sequencing; Spat Span = Spatial Span; Auditory Rec. = Auditory Recognition.*

Summary of Results

SC presented with below average performance on two of the six auditory comprehension subtests. There was marked variability in his performance across subtests, with scores ranging from above average to below average.

3.2 Case Study Discussion

3.3.1 Patterns of Performance

Five of the six adolescents who suffered TBI during childhood scored below the 10^{th} percentile on at least one subtest of the auditory comprehension battery. The sixth participant, although scoring within the average range on these measures showed marked variation in performance, gaining scores at either end of the average range. Five of the six adolescents with TBI also scored below average on a measure of working memory, the Letter-Number Sequencing subtest of the *WMS-III.* The participant, who did not score below average on this measure, had significantly impaired performance on a different memory measure, Verbal Paired Associates (I and II).

The performance of the adolescents with TBI was generally inferior to that of their age-matched peers. In each case study however, there was at least one measure of comprehension or working memory where the individual with TBI performed at the same level or higher level than that of control participants. Despite this, all participants with TBI reported academic difficulties whereas none of the age-matched controls were identified as displaying academic problems.

3.3.2 *Working Memory and Language*

The findings that most participants with TBI had some identified working memory and language comprehension weakness is consistent with studies demonstrating a relationship between working memory and language comprehension (Daneman & Carpenter, 1981; Just & Carpenter, 1992). The findings also support a hypothesis that impaired working memory negatively impacts language comprehension performance. However, the performance of two participants appears contrary to this hypothesis. One student (CV) did not present with impaired performance on any working memory measure yet still exhibited deficits in all but one area of listening comprehension. A second student (JW) demonstrated impaired performance on a working memory measure (Letter-Number Sequencing task of the *WMS-III*) but did not perform below average on any of the comprehension subtests. One possible explanation for CV's performance is that although working memory was not impaired, capacity limitations existed. The normal constraints of CV's working memory may not have allowed sufficient resources to be allocated to compensate for an impaired linguistic system. It could be hypothesized that his language performance would be enhanced if he had greater capacity in working memory. This can be evaluated to some extent by comparing CV's performance on tasks that have high working demands but is best tested by deliberately manipulating the variables that facilitate or constrain working memory.

JW's success on comprehension tasks despite some working memory impairment requires closer examination of performance across the various tasks. Significant discrepancies across comprehension subtests were evident. His exceptional abilities in receptive vocabulary were inconsistent with his relatively weak performance (low-average range) on the Figurative Language Comprehension subtest. Variability in the scores may have reflected the different processing and storage demands of the tasks in the presence of a relatively impaired working memory system. That is, the figurative language comprehension task required greater processing and storage resources than the receptive vocabulary tasks which simply required JW to point to a named picture when given a choice of 4 pictures to select from. With the exception of figurative language comprehension, which required JW to integrate the linguistic information presented with world knowledge, JW's seemingly intact linguistic system permitted him to perform strongly on the tasks despite reduced working memory resources. It is conceivable that the limitations in working memory capacity would result in impaired performance on highly integrative tasks such as essay composition, which is consistent with reports regarding JW's academic performance.

For all participants there was variability in performance across tasks. Although some variability is naturally expected, the large discrepancies in scores for some participants warrant further investigation. In order to explore this variability and to examine the language performance relative to working memory, it is essential to consider the working memory demands of the measures employed.

Performance on Tasks with Low Working-Memory Demands

The *PPVT-III* was predicted to make the fewest demands on working memory. For four of the six adolescents, the *PPVT-III* scores were higher than scores on the additional comprehension subtests. The exceptions were with AR and CV. AR performed as poorly on the *PPVT-III*, as she did on other listening comprehension tasks that were expected to make greater working memory demands such as the Listening Vocabulary subtest. For this student then, working memory demands alone could not explain performance outcomes. Rather, it is plausible that AR's very low vocabulary scores were related to her persistent reading difficulties. Students who are proficient readers have more extensive vocabularies than students who are poor readers as word knowledge in late childhood and adolescence is extended through written language experience (Nippold, 1998).

CV performed better on a comprehension task with high working memory demands (gaining a score at the 63rd percentile on the Listening Grammar subtest) than he did on the *PPVT-III* with low working memory demands. The unexpected outcome may be explained by considering the linguistic processing involved in the Listening Grammar task. Listening Grammar involved syntactic processing, which appeared to be intact for CV, whereas other tasks such as Figurative Language Comprehension or Listening Vocabulary required semantic processing. CV appeared to have impaired semantic processing and so performed poorly on tasks with semantic processing requirements. It could be argued that CV's performance was a result of an isolated impairment in the semantic system (i.e. distinct from working memory). However, the discrepancy in CV's performance across tasks requiring semantic processing suggests an interaction between working memory and the linguistic system. That is, CV's performance on semantic tasks with low working memory demands (e.g. *PPVT-III*) was relatively stronger than on semantic tasks with high working memory demands (e.g. Figurative Language Comprehension).

Medium and High Ranked Working Memory Tests

Five of the six participants scored below average on at least one of the tasks ranked as having medium to high working memory demands. One participant, JW, scored within normal limits on all language tasks but had relatively poor performance on the Figurative Language subtest which was ranked as having high working memory demands. There was considerable variability on tests with higher working memory demands both within and across participants. Factors inherent to the tasks may have facilitated or constrained working memory and influenced performance. For instance, tasks that were familiar may have allowed participants to draw on world knowledge and achieve higher scores. In light of the variability, examination of individuals' performance on tasks requiring medium to high working memory demands was undertaken.

Participant 1 (AR)

AR's performance on two comprehension subtests with high working memory demands (inference comprehension and figurative language subtests) was severely impaired. However, AR's performance on the Listening Grammar subtest, which was also ranked as having high working memory demands, was relatively strong although not age-appropriate. It has been proposed that the syntactic system may not be impaired following TBI. If AR's syntactic system was relatively intact, performance on the Listening Grammar subtest may be impaired because of the high storage demands. However, the impairment would not be as marked as tasks with high working memory demands that involved an inefficient linguistic system.

An unexpected finding in AR's comprehension profile was her within-average performance on discourse comprehension (Listening to Paragraphs). Working memory demands of the Listening to Comprehension subtest were estimated to be high and poor performance was predicted. The inconsistency between predicted and actual performance may be related to factors that facilitate working memory, such as familiarity. Familiarity is expected to increase automaticity of processing, hence decreasing processing requirements. The passages used in the Listening to Paragraphs subtest were designed to represent situations that school-aged children may encounter. The situations may have been sufficiently familiar to AR to decrease processing resources, making greater resources available for storage of information presented in the text. Likewise, familiarity may have allowed AR to draw on world-knowledge to answer the questions.

Participant 2(AH)

Although AH performed best on the task with least working memory demands (*PPVT-III*), her performance on tasks with medium to high working memory demands was within normal limits, with the exception of discourse comprehension (Listening to Paragraphs). . Preserved performance on the Listening Grammar subtest could provide further support for the relative sparing of syntactic processing in TBI. For other tasks (i.e. Making Inferences and Figurative Language Comprehension), it could be surmised that a factor such as familiarity facilitated working memory and hence, comprehension.. For instance, familiarity has been shown to improve understanding of idioms (Nippold & Rudzinski, 1993; Nippold & Taylor, 1995). Familiarity was also reported to lessen constraints on working memory and make processing more automatic, allowing more resources for storage. The figurative language subtest of the *TLC-E* is made up of familiar idioms (Wiig & Secord, 1989). Considering AH has relatively strong literacy skills, she would likely have been exposed to idioms in texts at school and in her general reading. Her familiarity with the idioms may have supported her comprehension.

AH's low performance on the Listening to Paragraphs subtest would suggest comprehension for that task was not facilitated by familiarity. Rather working memory may have been constrained by increased storage demands related to the relatively large amount of information that was presented. For other tasks, such as Inference Comprehension, the storage demands were lessened somewhat because a written version of the task was presented. For Listening to Paragraphs, the information was presented once auditorily, and then stored and processed simultaneously. This was particularly difficult for AH, as she demonstrated impaired performance on the Logical Memory Subtest of the *WMS-III*, which has similar task requirements to the Listening to Paragraphs subtest.

Participant 3 (RH)

RH scored at the low end of average or below average on subtests predicted to have medium to high working memory demands. The most notable result in RH's profile however, was the low Listening Vocabulary subtest score. The Listening Vocabulary subtest was predicted to have low to medium working memory demands. Two meanings of one word must be accessed (which is thought to occur relatively automatically) and held in storage so that the two possible meanings could be identified. In light of RH's average score on the *PPVT-III*, it would be expected that she would have the vocabulary knowledge to perform the test adequately. One possibility is that when a word is heard, the most common meaning is accessed very quickly and relatively automatically. In a testing situation, that meaning is stored allowing the examinee to compare the various picture options and select the one that best matches the lexical meaning. Two possible obstacles may be encountered when trying to access the second meaning. First, the alternative meaning may require greater processing resources in order to be accessed because it is less familiar and less automatic. Sufficient resources may not be available for retrieving the alternate meanings. A second possibility is that in order to retrieve the alternate meaning, the original meaning must be suppressed. It has been proposed that working memory is required for the process of inhibiting or suppressing unwanted information (Stoltzfus, Hasher & Zacks, 1996). According to this theory, individuals with working memory impairment have more interference from distractors and non-essential information. In work with older adults, Hasher & Zacks (1996) have found that they have difficulty in eliminating activated information even when it becomes irrelevant. A similar process may account for RH's difficulties in the Listening Vocabulary task.

Participant 4(CV)

CV had significantly impaired performance on all tasks with medium and high working memory demands with the exception of the Listening Grammar subtest 63rd percentile). Successful performance on the Listening Grammar subtest in the presence of severely impaired scores in other areas may reflect intact syntactic processing and impaired semantic processing. This supports the tenet that language performance is influenced by the interaction between working memory and language and not either one or the other.

Particpant 5 (JW)

JW scored within normal limits on all tasks in the auditory comprehension battery. His scores on tests with medium and high working memory task demands however were weaker than performance on tasks with low working memory demand (Figure 3.9 highlights the performance difference between the Figurative Language Comprehension with high working memory demands and the *PPVT*-III) with low working memory demands. Although caution is needed in interpreting differences within the normal range, it is plausible to suggest that JW's working memory difficulties (as evidenced by poor performance on the Letter-Number Sequencing subtest of the *WMS-III*) influenced his comprehension.

Particpant 6 (SC)

SC's performance on comprehension tasks could not easily be explained by working memory demands. His performance varied widely across subtests that made medium and high working memory demands such as Listening Grammar, Figurative Language Comprehension and Listening Comprehension: Making Inferences (25th, 50th and 2nd percentile, respectively). As with the other adolescents with TBI, performance differences may have reflected relative processing strengths (e.g. syntax processing) and weaknesses or increased familiarity for some tasks (e.g. figurative language expressions).

3.3.3 Comparison of Results to Alternative Models

In addition to working memory as an explanation for how adolescents with TBI perform on language comprehension tasks, two alternative hypotheses must be considered. One hypothesis was that skills that were developing, particularly rapid developing skills, were more likely to be impaired following TBI (Dennis, 1989; Ewing-Cobbs et al., 1987). The second was that high-level language skills such as inference and figurative language comprehension are more likely to be impaired (Hinchliffe et al., 1998; Jodan & Murdoch, 1994). The findings were examined in relation to the two hypotheses.

Rapid Development Hypothesis

There is some support for the rapid development hypothesis within these findings. First, AR, who sustained her head injury at a very young age demonstrated significant deficits in language comprehension across the majority of subtests. Both AH and RH sustained their head injuries around the time when understanding of multiple meanings is rapidly developing (Nippold et al., 1996). Both participants showed deficits in those areas. In addition, AR who sustained her head injury at a very young age, demonstrated impairment across all the areas of language comprehension that were tested.

They rapid development hypothesis is problematic in several respects however. First, JW sustained an injury at a very young age and demonstrated normal performance across all tests. However, it could be argued that because JW sustained a mild TBI, language comprehension would be expected to be spared. Still the model does not explain variability in performance within an individual. For instance, the hypothesis is partially supported by SC's results. He did relatively better on syntax, which could have been more established at the time of his accident than understanding of multiple meanings or inference comprehension. The model does not easily explain his average performance on figurative language comprehension however, which continues to develop in late childhood and adolescence, nor does it account for difficulties on the Listening to Paragraphs subtest. The hypothesis may be more suited for directing the types of tests we choose, rather than describing the nature of the deficit.

High-level Language Hypothesis

Two-thirds of the adolescents with TBI demonstrated difficulties with tasks described as high-level language tasks such as inference comprehension and figurative language comprehension. The two participants who did not score below average on those tests, had lower scores relative to simpler language tasks such as Receptive Vocabulary. There was great variability in performance on those tasks between and within participants and within each individual task. For instance, AR and CV both performed very poorly on the Listening Comprehension: Making Inferences Subtest but did understand some of the inferences that were made. Others (e.g. SC) did well on one high-level language test and poorly on another. The notion that high-level language tasks are more impaired than basic language tasks has received some merit in these findings however the hypothesis is not sufficient to explain the variability in performance noted in all participants.

3.3 Discussion

The study described in this chapter investigated the listening comprehension profiles of adolescents who suffered a TBI during childhood and examined whether the profiles of these participants differed from typically developing peers. Six adolescents, aged between

12 and 16 years, who a suffered a TBI prior to 11 years of age participated in the study. Each individual's performance was compared to an age-matched peer from the same, or similar, education and socio-economic environment on a range of comprehension and working memory measures. Examination of individual participants revealed 5 of the 6 participants with TBI demonstrated listening comprehension deficits on at least one measure of comprehension assessed. For the age-matched controls, no individual scored below the 10th percentile on any of the comprehension measures.

Overall, the adolescents with TBI performed more poorly in listening comprehension than their age-matched control. This finding was consistent with the academic difficulties reported by the participants with TBI and, in particular, is consistent with their persistent reading inefficiencies or writing difficulties. However the pattern of listening comprehension impairment differed across individuals and marked variability within the comprehension profiles for some individuals with TBI was evident.

Consistent with previous literature (e.g. Docking et al., 2000; Jordan & Murdoch, 1994), a general trend was shown for the participants with the greater severity of injury to exhibit the weakest listening comprehension performance, but a depressed profile across all comprehension subtests was not demonstrated. Further, one participant who suffered a severe head injury, AH, performed well on most of the comprehension subtests. Several factors need to be considered in addition to the severity of the TBI in interpreting the individual's comprehension profiles.

One factor that the literature reviewed identified as important to consider in comprehension performance is the role of working memory. A secondary aim of the study reported in this chapter was to document the memory profiles of adolescents with TBI and to examine the contribution of working memory to performance on the comprehension tasks.

Working memory capacity has been associated with listening and reading comprehension in children and adults with and without language impairment. Five of the six participants with TBI scored below average on the Letter-Number Sequencing, which was a measure of working memory. One participant, CV, scored within normal limits. Additionally, all participants except CV achieved their best results on the *PPVT-III*, which was predicted to have the fewest working memory requirements. For those participants, scores on tests with higher working memory demands were markedly below the scores on the *PPVT-III*.

Variability within and across subtests can be explained within a working memory model. Differences across subtests may be explained by factors that constrain or facilitate working memory. The processing demands of certain tasks may vary across subjects. For instance, figurative language and inference comprehension were predicted to have high working memory demands. Two-thirds of the participants had difficulties on at least one of those tasks. Understanding for those participants who did not have difficulty may have been facilitated by a factor such as increased familiarity with the content of the task. In addition, some participants may have had specific processing strengths tasks such as Listening Grammar. Differences in processing demands may explain why the Listening Grammar subtest was a relative strength for all participants. CV achieved his highest score on the Listening Grammar subtest. Participants 2, 3, 5 and 6 all scored within normal limits for Listening Grammar and participant 1(AR) scored at the 9th percentile (as compared to the 1st and 2nd percentile for Inference Comprehension and Figurative Language). It has been demonstrated that the storage demands of the Listening Grammar subtest may impair performance in adolescents with TBI (Turkstra & Holland, 1998). It may be however, that in spite of increased storage demands, the relative automaticity of syntactic processing may have facilitated performance. The items in the *TOAL-3* Listening Grammar subtest do not include object-relative sentences or ambiguous sentences. Although some of the syntactic structures are later developing, they may remain relatively automatic in their processing.

Working memory may have also contributed to the overall poor performance on the Listening Vocabulary subtest of the *TOAL-3*. All participants had relatively low scores for understanding of multiple meanings particularly when compared to the *PPVT-III*. Although understanding of multiple meanings was not predicted to have high working memory demands, analysis of the processes involved in interpretation of multiple meanings may suggest otherwise. When a word with multiple meanings is presented, both meanings are expected to be retrieved automatically (Miyake et al., 1995). However, if one meaning is less familiar, it is possible that the familiar meaning will be more strongly activated. It may then take extra processing resources to suppress the familiar meaning in order to identify the alternative meaning. Suppression or inhibition of information has been put forward as a primary component process of working memory (Hasher & Zacks, 1996).

It is difficult to predict the working memory demands of any given task without testing it directly. Although storage demands may be relatively predictable, processing demands vary across tasks and even across individuals. One method of assessing processing demands may be to alter processing demands of a task and observing differences in performance (e.g. King & Just, 1991). An alternative method is to predict processing demands based on research and manipulate storage demands. In the upcoming studies, processing and storage variables are manipulated and the affect of that manipulation on comprehension performance for adolescents with TBI is evaluated. Assessing and understanding the affects of task demands on listening performances is critical in to understanding the relationship between working memory and listening comprehension in individuals with TBI.

The relationship between listening comprehension of adolescents with TBI to the "rapid developing hypothesis" and the "high-level language hypothesis" is partially supported by this model. These models have two primary problems however. First, they do not explain the variability in performance that occurs in adolescents with TBI. Second, they are difficult to test experimentally. Docking et al. (1999, 2000) examined Barnes' (1988) developmental hypothesis. They argued that although it held some merit, it may be best considered as an independent variable. The two hypotheses warrant consideration when assessing individuals with TBI. Tests that are developmentally appropriate, that target later developing forms and that target high-level language skills should be included in an assessment battery. Because high-level language tasks are assumed to be more complex, further exploration of the relationship of working memory to performance on high-level language tasks such as figurative language and inferencing would be warranted.

This study has shown that adolescents with TBI do have difficulty with auditory comprehension. Particular areas of weakness that were identified included understanding of multiple meanings, inference and figurative language comprehension and discourse comprehension. The overall profile of auditory comprehension is variable but may be related in part to working memory. In order to further examine the relationship between working memory and listening comprehension, task demands must be evaluated and, where possible, working memory demands manipulated. It may be particularly useful to manipulate task demands on complex linguistic tasks such as figurative language comprehension and inference comprehension.

CHAPTER 4: PROVERB COMPREHENSION IN NEW ZEALAND YOUTH

4.0 Introduction

Figurative language comprehension has been identified as an area of impairment in children and adolescents with traumatic brain injury (Jordan et al., 1996). Conflicting results, however, are reported in the literature. Although poor performance on a measure of figurative language (*Test of Language Competence-Expanded TLC-E,* Wiig & Secord, 1989) has been demonstrated in some studies (e.g. Jordan et al., 1996), other investigations concluded that figurative language is not impaired in adolescents with TBI (Towne and Entwhistle, 1996). The description of the language comprehension profiles of adolescents who suffered TBI presented in Chapter 3 also revealed inconsistencies across individuals. Three of the case studies described in Chapter 3 performed below average on understanding figurative language while the remaining three participants achieved age-appropriate performance.

It has been demonstrated that task demands can influence performance on tests of language comprehension (Turkstra & Holland, 1998). Individuals with impaired working memory may be particularly sensitive to variation in task demands. The inconsistent results in studies of figurative language comprehension may, therefore, be related to the interaction of working memory and task demands. Further, the nature of the task used to assess understanding of figurative language, as well as working memory capacity may influence performance outcomes. The stimulus items on the Figurative Language Comprehension subtest of the *TLC-E* (the most commonly used measure of figurative language) are idioms and metaphors that are frequently used in English (Wiig & Secord, 1989). Familiarity with context of spoken language has been shown to increase automaticity of processing and lessen working memory demands (Yekovich et al., 1996). In addition, familiarity of figurative expression such as proverbs and idioms is associated with improved comprehension in typically developing adolescent populations (Nippold & Haq, 1996; Nippold & Rudzinski, 1993; Nippold & Taylor, 1995) and in persons with brain damage (Brundage, 1996). It has been hypothesized that idioms and proverbs that are familiar are stored as a single unit with an associated meaning (Swinney & Cutler, 1979). When figurative expressions are not familiar, an individual is required to abstract meaning from the individual words as well as the context (Nippold & Rudzinski, 1993). It is likely that this contextual abstraction would involve large working memory demands as the entire expression would have to be stored while an analysis of its component parts and context cues would be made. It may be hypothesized that adolescents with TBI who have reduced working memory capacity may have adequate performance on those figurative expressions that are familiar, but poor performance on items that are unfamiliar. In order to evaluate whether adolescents with TBI comprehend figurative language expressions they encounter that are unknown, it is important to utilize tasks that control for familiarity.

One task that has controlled for familiarity, among other factors (e.g. concreteness and abstractness of the proverb), is the *Proverb Comprehension Task (PCT)*(Nippold, Allen, & Kirsch, 2000). The *PCT* has been developed and employed over a series of studies carried out by Nippold and colleagues (Nippold et al., 2000; Nippold & Haq, 1996; Nippold, Hegel, Uhden, & Bustamante, 1998; Nippold, Martin & Erskine, 1998; Nippold, Uhden & Schwarz, 1997). The *PCT* employs a multiple-choice format, which examines the students' understanding of 20 proverbs, half concrete and half abstract. All proverbs are of low-familiarity so that students are required to actively analyse the expressions, and cannot simply recall their meanings from past learning experiences. The ability to analyse proverbs was of interest to Nippold and colleagues because such analysis is likely to occur when students encounter proverbs in reading or listening to literate language. The ability to analyse proverbs was also of interest in the study reported in this chapter as the ability to successfully comprehend proverbs may be constrained by a reduced working memory capacity.

Proverb comprehension involves higher order cognitive skills such as verbal reasoning, knowledge of abstract nouns, the ability to infer meaning from context, and an awareness of the thoughts and feelings of others (Nippold, Allen, & Kirsch, 2001). Adolescents with TBI reportedly have difficulty with high-level language skills (e.g. Hinchliffe et al., 1998) and hence it may be predicted that they will encounter difficulties on proverb comprehension tasks. It is important for adolescents to have sound understanding of proverbs as they frequently occur in diverse forms of spoken and written communication such as lectures, political speeches, religious services, popular music, books, magazines, and newspapers (Borland & Durst, 1999; Gibbs & Beitel, 1995; Mieder, 1993). Because proverbs express the collective values, beliefs, or wisdom of a society (Mieder, 1993), the understanding of these expressions contributes to cultural literacy (Hirsch, Kett, & Trefil, 1988). To a large extent, the enduring quality of proverbs stems from the many pragmatic functions they can be called upon to serve. For example, proverbs can be used to encourage (Every *cloud has a silver lining*), warn (*Look before you leap*), or inspire (*Mighty oaks grow from little acorns*) other people, or to comment on objects or events that people experience (*A picture is worth a thousand words*). In schools today, students encounter proverbs in their literature books, often in the form of fables, which they are asked to read and analyse in relation to the contemporary world (e.g., Wood, McDonnell, Pfordresher, Fite, & Lankford, 1991). Prior to using the *PCT* with adolescents with TBI, further evaluation of the psychometric characteristics and the usefulness of using the task with a New Zealand population is necessary.

The present study had two aims. The first aim was to examine the development of proverb comprehension in New Zealand students using the *PCT* (described in detail in section 4.1), and to compare their performance to that of age-matched American youth. It is important to obtain data for typically developing New Zealand children to compare to compare to a disordered population so that cultural bias is eliminated. It was of interest also to determine if performance on the *PCT* would be associated with New Zealand students' level of academic achievement in the areas of reading comprehension and listening comprehension. Previous research had established that proverb understanding was associated with reading comprehension in American youth (e.g., Nippold et al., 1988, 1998). However, it would seem the association with listening comprehension had not been examined in students from any country. It was predicted that both reading and listening comprehension would be associated with proverb understanding because both are major sources of language-learning input for children and adolescents (Choate & Rakes, 1987; Funk & Funk, 1989; Perera, 1986).

The second aim was to use the *PCT* to examine proverb comprehension in adolescents with TBI (described in Experiment 2). In addition the relationship between working memory span and proverb comprehension was evaluated for adolescents with TBI to determine if working memory capacity influenced comprehension performance, particularly for unfamiliar proverbs.

4.1 Experiment 1

4.1.1 Participants

The participants in this investigation were 100 New Zealand students and 100 American students. Each cultural group contained 50 12-year-olds [New Zealand: mean age

= 12:4, range = 11:8 - 12:11; American: mean age = 12:2, range = 11:3-12: 10 and 50 14-year-olds [New Zealand: mean age = 14:3, range = 13:6-14:11; American: mean age = 14:8, range = 13:6-14:91. The ratio of boys to girls for each cultural and age group was as follows: New Zealand age 12 = 1:1.9; American age 12 = 1:1.0; New Zealand age 14 = 1:1.0; American age 14 = 1:0.85. In total, there were 94 boys and 106 girls (1:1.13) participating in the study from both countries.

The New Zealand students were attending a public primary school (Year 8) or secondary school (Year 10) in Christchurch while the American students were attending a public middle school (Grade 6 or 8) in western Oregon. All students spoke the standard English dialect of their country, and according to their teachers, were free of any known disorders of speech, language, hearing, or cognition. No students were receiving special education services.

4.1.2 Procedure

The same procedures were used to administer the *Proverb Comprehension Task (PCT)* to students from both countries. All students were tested as a group during their regular classes at school. Two examiners went into each classroom and conducted all aspects of the testing. While one examiner spoke to the group, the other walked around the classroom to ensure that all students were attending to the directions and following along in their test booklets. The session began with a brief explanation of the study, indicating that its purpose was to learn about young peoples' knowledge of figurative language. The steps involved in completing the task were described, and two practice problems, similar in format to the test problems, were presented. After the group completed the practice problems, the examiners confirmed the correct responses and answered any questions before the students began working on the test problems.

4.1.3 Materials

Proverb Comprehension Task

As discussed above, the *PCT* had been developed for a previous study (Nippold et al., 2000). The task employed a written multiple-choice format, and consisted of a set of 20 proverb problems, presented in random order, which the students read silently. All proverbs were of low-familiarity, as determined in another previous study (see Nippold & Haq, 1996, for details), and each was a declarative sentence that contained two nouns. Half of the proverbs were concrete in that their nouns referred to tangible objects *(Every bird likes its own nest best)*, while the other half were abstract in that their nouns referred to intangible concepts *(e.g., An optimistic attitude is half of success).* Each proverb was presented in a brief story context that supported but did not give away its figurative meaning. Each story consisted of four sentences. The proverb always occurred in the final sentence and was spoken by a character in the story. The student was asked the meaning of the proverb, and was provided with a choice of four answers, one which best explained the proverb. The three foils were some way related to the story, making it necessary for student to read all four choices carefully before, selecting the best one. The *PCT* was written at a fifth-grade level (Fry, 1968), which is equivalent to Year 6 in Zealand. Because the task was designed originally for Americans, some small but important lexical were made when it was language. For example, on the New Zealand version of the *PCT Auckland* replaced *Arizona, rugby* replaced *football* and *car-park* replaced *parking lot.* Examples of problems from the New Zealand version of the task are as follows:

Concrete Proverb:

Emily begged to go to a computer camp in Auckland during the summer. Her parents agreed, and she was gone for two weeks. She enjoyed the camp and made new friends, but she missed her family more than she had expected. Her mother said, "Every bird likes its own nest best."

What does it mean to say, *Every bird likes its own nest best*?

A. New experiences can help people grow

B. People often want to be on their own

C. People are often more comfortable at home

D. It can be fun to visit faraway places

Abstract Proverb:

Beth and Lisa took an algebra class together. Before the class began, Beth said she expected to earn an A in the class because she was good at maths. When Beth got an A and Lisa got a C, Lisa commented on how smart Beth was. Their teacher said, "An optimistic attitude is half of success."

What does it mean to say, *An optimistic attitude is half of success*?

A. Sometimes life can be unfair

B. It's important to believe in yourself

C. Hard work will pay off in the end

D. Different people have different skills

In a previous study (Nippold et al., 2000), the *PCT* had been subjected to a construct validity measure, which determined that, in order for adults (university students) to perform adequately on the task (accuracy > 90%), it was necessary for them to interpret the proverbs as opposed to being able simply to read the story contexts and the answer choices. Hence, the *PCT* was more than a test of reading comprehension in that it required the individual to analyse the proverbs. Also in that same study, the test-retest reliability of the *PCT* was determined to be adequate ($r = .87, p < .0001$) when it was administered to American students in group fashion.

However, because the *PCT* had never been administered in New Zealand, it was deemed important in the present study to obtain an estimate of test-retest reliability with New Zealand students. This was accomplished by administering the task a second time to 23 of the Year 8 students (7 boys, 16 girls) who were available four weeks followings the first administration (using scores on the first administration for the main experiment). The procedures employed to administer the task the second time were identical to those used the first time. Mean raw scores obtained by the students on the first and second administrations respectively, were 10.22 (SD = 3.88; range = 4-17) and 10.61 (SD = 4.91: range = 4.91: range = 4-20). The correlation coefficient obtained between the two sets of raw scores was statistically significant and strongly positive ($r = .84, p < .0001$), and a paired t-test failed to yield a statistically significant difference between scores ($t = 0.71, p > .05$). This indicated that the *PCT* has adequate stability (Salvia & Ysseldyke, 1981) when administered to New Zealand students in group fashion at school.

Progressive Achievement Tests

The New Zealand students had been administered the *Progressive Achievement Tests (PATs)* (New Zealand Council for Educational Research, 1994) one month before they were administered the *PCT*, and scores on the Reading Comprehension and Listening Comprehension tests were available for all 100 participants. In New Zealand, the *PATs* are administered annually to children ages 8 through 14 years to monitor their progress in school, and to identify any students in need of assistance to improve their academic performance. As a result of extensive psychometric scrutiny and revision of the *PATs*, it had been determined that both Reading Comprehension and Listening Comprehension have adequate concurrent validity and test-retest reliability. Unfortunately, scores on a comparable tool were unavailable for the American students in the present study.

The procedures for administering the *PATs* are similar to those for administering the *PCT*. Students are tested in large-group fashion at school, and mark their answers in individual text booklets. For Reading Comprehension, they are asked to read silently passages of up to 300 words in length, written in a variety of genres (e.g., narrative, expository, descriptive), and to answer questions tapping their understanding of information that was stated explicitly (factual comprehension) as well as their ability to go beyond the stated information to draw conclusions or make other types of generalisations (inferential comprehension). Listening Comprehension is identical to Reading Comprehension except that the teacher reads passages aloud to the class, followed by the same types of questions. Up to 48 points can be earned for each test.

4.1.4 *Results*

Table 4.1 contains the mean raw scores, standard deviations, and ranges obtained on the *PCT*. The New Zealand students, ages 12 and 14 years, respectively, earned overall accuracy scores of 60% and 70%, while the Americans, ages 12 and 14 years, respectively, earned overall accuracy scores of 56% and 67%. The data were analysed using, a 2 x 2 x 2 (age x culture x gender) ANOVA. A significant main effect was obtained for age [F (1, 192) = 15.14, p <.0001] but not for culture [F (1, 192) = 1.46, p >.05] or gender [F (1, 192) = 1.05, p >.05]. Based on standards of behavioural research (Cohen, 1988), the effect size for age, computed by Cohen's d, was moderate (d =.53). Dependent t-tests indicated that the abstract proverbs were more difficult than concrete proverbs for both age groups (Age 12; t = 4.28, p <.0001; Age 14; t = 5.49, p <.0001). Effect sizes computed by Cohen's d were moderate (Age 12: d = .36; Age 14: d =.53).

Table 4.1. Results of the Proverb Comprehension Task for the four groups of student (n = 50) and for all students combined.

	Age 12		Age 14		All
	NZ	AM	NZ	AM	
Total Correct (20 possible)					
Mean raw score	12.02	11.24	13.94	13.44	12.66
SD	4.04	4.01	3.66	3.46	3.92
Range	4–18	3–19	4–20	5–20	3–20
Concrete (10 possible)					
Mean raw score	6.34	6.08	7.64	7.08	6.79
SD	2.29	2.45	1.80	1.64	2.15
Range	1–10	1–10	3–10	3–10	1–10
Abstract (10 possible)					
Mean raw score	5.68	5.16	6.26	6.36	5.87
SD	2.20	1.89	2.17	2.36	2.20
Range	1–9	1–9	0–10	1–10	0–10

NZ = New Zealand; AM = American

Table 4.2 lists the proverbs in order of increasing difficulty, based on the performance of all 200 students combined. For each proverb it also shows the mean accuracy score obtained by each age group and cultural group, and by all students combined. Inspection of this table indicates that, with a few exceptions (e.g., # 1, 3, 12), patterns of proverb ease and difficulty for New Zealand and American students of the same ages were quite similar (e.g., # 2, 4, 5, 6, 7, 8, 9, etc.).

Table 4.2. Proverbs listed in order of increasing difficulty, shown with the mean accuracy scores for each group of students (n = *50 per group) and for all students combined).*

		Age 12 (%)		**Age 14(%)**		
		NZ	**AM**	**NZ**	**AM**	**All**
1	Every bird likes its own nest best (CON)	88	78	84	90	85
2	A mouse may help a lion (CON)	82	82	86	86	84
3	Sorrow is born of excessive joy (ABS)	72	82	74	98	82
4	The restless sleeper blames the bed (CON)	70	70	88	80	77
5	Courage is always better than cowardice (ABS)	76	74	80	78	77
6	A caged bird longs for the clouds (CON)	78	72	74	76	75
7	Scalded cats fear even cold water (CON)	52	58	88	86	71
8	A good sailor likes a rough sea (CON)	64	60	78	78	70
9	A forced kindness deserves no thanks (ABS)	64	64	68	72	67
10	Expectation is better than realisation (ABS)	62	58	76	64	65
11	Gratitude is a heavy burden (ABS)	62	58	54	78	63
12	Every horse thinks its own pack heaviest (CON)	66	52	74	52	61
13	Every bird must hatch its own eggs (CON)	54	44	70	64	58
14	Humility often gains more than pride (ABS)	56	52	72	48	57
15	An optimistic attitude is half of success (ABS)	58	28	72	62	55
16	The pretty shoe often pinches the foot (CON)	36	50	62	52	50
17	Two captains will sink a ship (CON)	44	42	60	44	48
18	A wonder lasts but nine days (ABS)	46	42	52	50	48
19	Envy is destroyed by true friendship (ABS)	38	34	44	42	40
20	Of idleness comes no goodness (ABS)	34	24	34	44	34

CON = concrete; ABS = Abstract; NZ = New Zealand; AM = American

Table 4.3. Performance of the New Zealand students (n 50 per group) on the Listening and Reading Comprehension sections of the Progressive Achievement Tests

	Listening Comprehension		**Reading Comprehension**	
	Age 12	**Age 14**	**Age 12**	**Age 14**
Mean raw score	31.70	32.62	26.08	29.30
SD	6.16	7.06	7.18	7.69
Range	16 – 43	16 - 45	11 - 42	9-42

For the New Zealand students, performance on the Listening and Reading Comprehension sections of the *PAT*s is reported in Table 4.3. Dependent t-tests indicated that Reading Comprehension was more difficult than Listening Comprehension for both age groups (Age 12: $t = 7.63$, $p < .0001$; Age 14: $t = 4.00$, $p < .0002$). The effect size, computed by Cohen's *d*, was large for the 12-year-olds ($d = .84$) and moderate for the 14-year-olds ($d = .45$). For both age groups, Pearson product-moment correlation coefficients were computed between Proverb Comprehension and each section of the *PAT*, using each student's raw scores. As shown in Table 4.4, statistically significant coefficients were obtained in every case, indicating that students who had achieved higher scores on Listening and Reading Comprehension interpreted concrete and abstract proverbs with greater accuracy than their peers who had achieved lower scores on the tests. The correlation coefficients were moderately strong to very strong for the 12-year-olds, and moderately strong for the 14-year-olds (Schiavetti & Metz, 1997).

Table 4.4. Pearson Product-Moment Correlation Coefficients for the New Zealand students (n= 50 per group).

	Listening Comprehension		Reading Comprehension	
	Age 12	**Age 14**	**Age 12**	**Age 14**
Total Proverbs	.69***	.46**	.80***	.55***
Concrete Proverbs	.59***	.37*	.72***	.46**
Abstract Proverbs	.66***	.48**	.72***	.54***

* $p < .01$
** $p < .001$
*** $p < .0001$

4.1.5 Discussion

The results of this investigation indicated that the Proverb Comprehension Task was sensitive to age-related differences in the performance of 12- and 14-year-old typically achieving New Zealand and American youth, and that for both age groups, abstract proverbs were more difficult than concrete proverbs. The findings are consistent with previous developmental studies in demonstrating growth in proverb understanding as a function of increasing student age, and verifying the greater challenge posed by abstract over concrete proverbs during the preadolescent and adolescent years (Nippold & Haq, 1996; Nippold et al., 1997, 1998, 2000).

The results also showed that the New Zealand students did not differ from their age-matched American peers in comprehending the proverbs. This is reflected not only in the absence of statistically significant differences between cultural groups but also in the similar patterns of performance on the individual proverbs, evidenced in Table 2. Hence, the *PCT* appears to be free of cultural bias, at least with respect to the participants in this investigation. This is not to say that there are no differences in the frequency with which various proverbs occur in New Zealand versus American English. Rather, the absence of a cultural effect most likely stems from the fact that all of the proverbs on the *PCT* were of low familiarity, a condition that helped to ensure that students would attempt to actively interpret the expressions. A task that requires the active interpretation of proverbs is more challenging than one where the meanings can simply be recalled from past learning experiences, as might be possible had the task been comprised of very common proverbs. In addition to evaluating the task for using with NZ adolescents with TBI, the present study was part of a larger project to develop a proverb comprehension task that is sensitive to the language-learning abilities of students from a variety of English-speaking countries. In future research, it would be interesting to compare the frequency of occurrence of various proverbs in New Zealand and American English.

With respect to the New Zealand students, performance on the *PCT* was closely associated with skill in listening and reading comprehension. These results are consistent with previous research linking proverb understanding to reading comprehension, (e.g., Nippold et al., 1988, 1998) but extend the association to listening comprehension. It is reasonable to find these links with proverb understanding because listening and reading are major sources of language-learning input for children and adolescents (Choate & Rakes, 1987; Funk & Funk, 1989; Perera, 1986), and proverbs frequently occur in both spoken and written modes of communication (Gibbs & Beitel, 1995; Mieder, 1993). Students who excel in these areas may be gaining greater advantages from the exposure they receive to complex language through listening and reading.

In documenting links between proverb comprehension and skill in listening and reading comprehension, the results of this investigation suggest that the *PCT* is a sensitive index of literate language development. It should be noted that the task was determined to have adequate test-retest reliability when administered to New Zealand students, and that previously it was shown to have adequate test-retest reliability and construct validity when administered to American students (Nippold et al., 2000). These findings provide support for using the *PCT* more broadly in New Zealand and America to identify students in need of special assistance to facilitate their understanding of complex literate language. Additional groups of students should be tested in both countries to develop a larger normative database representing younger and older groups, diverse geographic locations, and varied socioeconomic levels. It is expected that this data collection process could be completed efficiently, because it has been found that the *PCT* can be administered quickly to large numbers of students and requires little time to score and interpret.

The findings of the study also support the use of the *PCT* for assessing adolescents with TBI. By controlling for factors that facilitate working memory and comprehension, such as familiarity, a better understanding of adolescents' understanding of figurative language, especially in contexts where the expression is unknown, can be achieved. The results also support examination of the relationship between working memory span and proverb comprehension. Like working memory span, proverb comprehension is related to listening and reading comprehension. This suggests the likelihood that working memory span is also related to proverb comprehension.

4.2 Experiment 2

4.2.1 Participants

The six adolescents with TBI and four of the age-matched peers who participated in Study 2 (See Chapter 3) were involved in this experiment. Two adolescents who did not take part in earlier studies were added to the control group. The two control participants who were added were age-matched with AR and CV, and were chosen from schools with a similar socioeconomic status to that attended by AR and CV. The participants ranged in age from 12 to 17 years and descriptive characteristics are reported in Chapter 3.

4.2.2 Materials

Proverb Comprehension Task

The same assessment was administered as in Experiment 1; however the administration procedures differed slightly. The task was administered by one examiner to each child individually in a quiet room at his/her school or home. Because listening comprehension was of interest, the items were read aloud to the students. Students were permitted one repetition of the entire stimulus item. They were also permitted to see the written version of the task. Instructions were read to the student as in Experiment 1.

Working Memory Tasks

Two working memory measures were used to assess working memory: Tompkins et al.'s (1994) Working Memory Task (WMT), and the Stroop test. The WMT was administered prior to the *Proverb Comprehension Task* and the Stroop test was administered following the *PCT.*

The Working Memory Task (Tompkins et al., 1994) consisted of 42 active declarative sentences. The sentences were divided into sets of two, three, four, and five. Three sets were administered per level (i.e. three sets of two sentences, three sets of three sentences, etc.). In order to make the test suitable to a New Zealand population, some lexical items were changed (E.g. *Florida is next to O*hio was changed to *Auckland is in the South Island*). Participants were instructed listen to the sentences, answer true or false, and then recall the final word of each sentence. Before beginning, the students completed some practice items. All items of the task were administered. .

The Stroop test was administered following the *PCT*. This version of the Stroop test had two conditions: colour naming, and colour-word naming. In the first condition, participants were presented with an A4 sheet of paper containing 100 coloured dots (red, black, blue, green, yellow). The dots were presented in five rows of 20. The participants had to name the colours as quickly as possible without error. The time taken for them to name the colours was measured. In the second condition, participants were presented with 100 colour names printed in a colour different to the word itself. Again 20 words were written across 5 rows and the participants had to name the colour of the ink as quickly as possible without error. The time taken was measured and the time difference between the two conditions was calculated. The Stroop test is depicted in Appendix C.

4.2.3 Results

Proverb Comprehension

Table 4.5 contains the mean raw scores, standard deviations, and ranges obtained on the *PCT* for the experimental and control groups. A t-test for independent means was calculated to compare the experimental and control group however no significant difference was found. Performance of individuals based on raw scores is represented in Figure 4.1. In most instances, the individuals with TBI performed below their non head-injured peers, however the differences are slight except for participant 1 (AR). When compared to the normative data collected in Experiment 1, two of the six adolescents with TBI had difficulties with the task. Participant 1 (AR) scored 2 standard deviations below the mean compared to the normative sample in Experiment 1. Participant 4 (CV) scored more than one standard deviation below the mean. The performance of participant 4 differed only slightly from an age-matched peer, but the performance of the control participant was within one standard deviation of the mean compared to the normative sample in Experiment 1.

Table 4.5. Results of the Proverb Comprehension Task for the two groups of students (n =6 per group).

	TBI	Control
Total Correct (20 possible)		
Mean raw score	12.67	16.60
SD	5.39	4.28
Range	5-18	9-19
Concrete (10 possible)		
Mean raw score	7.17	8.2
SD	2.99	2.95
Range	3-10	3-10
Abstract (10 possible)		
Mean raw score	5.5	8.33
SD	2.56	1.37
Range	1-8	6-10

TBI = Adolescents with TBI; Control =Age-matched controls

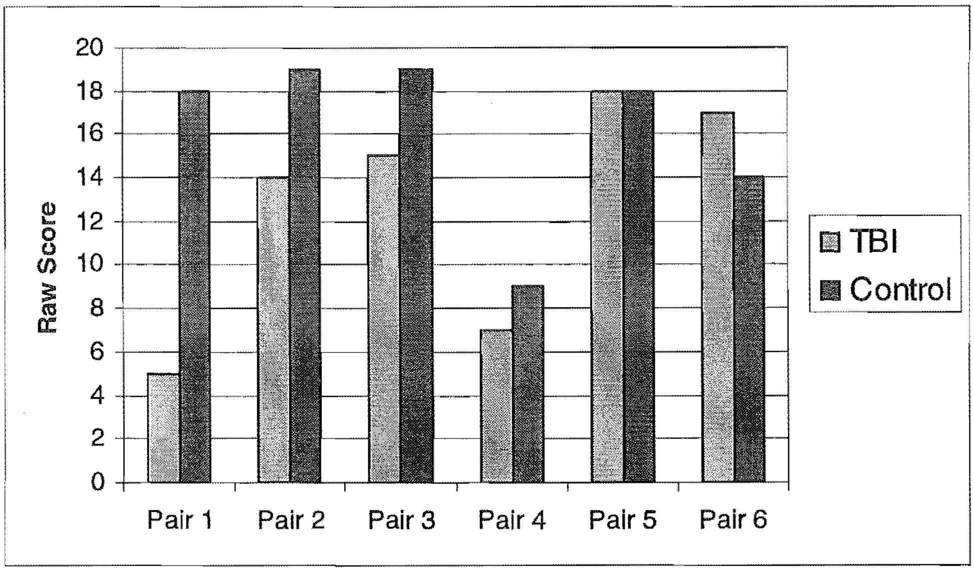

Figure 4.1. Raw scores for individual participants with TBI and age-matched controls on the PCT task (TBI = Adolescents with TBI; Control = Age-matched control participants). Each pair represents the individual with TBI along with their age-matched peer.

Differences in understanding for concrete versus abstract proverbs for the adolescents were evident. A paired t-test indicated that comprehension of abstract proverbs was more difficult than comprehension of concrete proverbs for adolescents with TBI ($t = 2.712$, $p < .05$). The effect size, computed by Cohen's d was moderate ($d = .53$). No significant difference was found for the age-matched controls, which is inconsistent with results from Experiment 1, however may be due to the small sample size. Individual differences in understanding of concrete versus abstract proverbs are depicted in Figure 4.2. Five of the six adolescents with TBI had greater difficulty with understanding of abstract proverbs. Participant 4 (CV) demonstrated little difference in understanding between concrete and abstract proverbs.

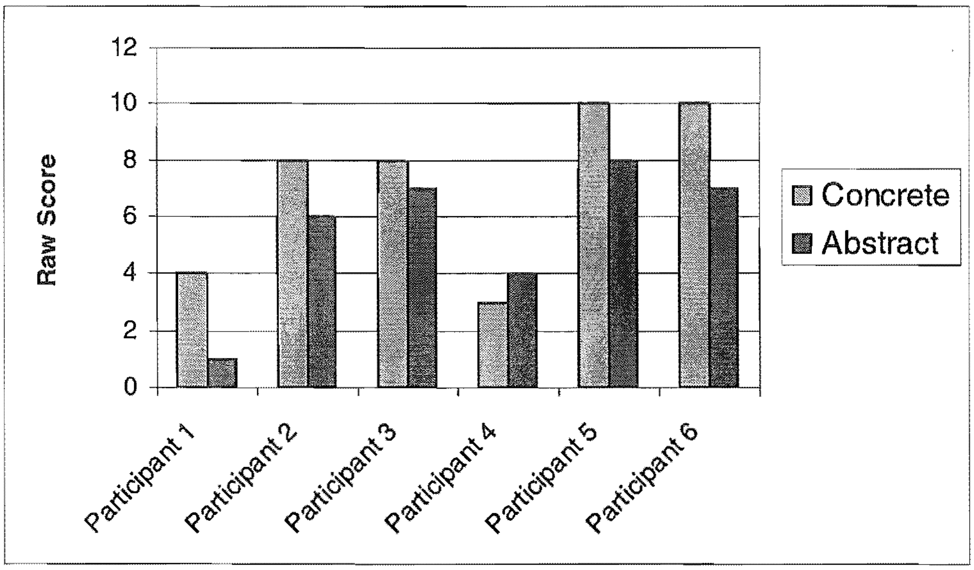

Figure 4.2. Raw scores for adolescents with TBI on the PCT for concrete and abstract proverbs.

Working Memory

Results of the working memory measures are reported in Table 4.6. No significant difference existed between the two groups on either the WMT or the Stroop Test.

Table 4.5. Results of the Working Memory Task and the Stroop test for the two groups of students (n = 6).

	TBI	Control
WMT* (42 possible)		
Mean raw score	28.00	32.80
SD	8.81	4.09
Range	15-37	28-37
Stroop (difference in seconds)		
Mean raw score	95.83	56.00
SD	60.51	12.98
Range	40-214	43-74

WMT = Tompkins et al.'s (1994) Working Memory Task ;

TBI = participants with traumatic brain injury;

Control = age-matched controls

For both participant groups Pearson-product moment correlations were calculated for Proverb Comprehension and the two working memory measures. As shown in Table 4.6, a statistically significant coefficient was found between Proverb Comprehension and Tompkins et al.'s Working Memory task for the TBI group for both concrete and abstract proverbs. A significant correlation was found between performance on the Stroop test and comprehension of abstract proverbs for adolescents with TBI. There was no significant relationship between performance on either working memory measure and proverb comprehension for the age-matched control participants. When the groups were combined however, a significant relationship was found between both working memory tasks and Proverb Comprehension.

Table 4.6. . Pearson Product-Moment Correlation Coefficients for the adolescents with TBI and the age-matched controls (n= *6 per group).*

	Adolescents with TBI		**Age-matched controls**		**All**	
	WMT	**Stroop**	**WMT**	**Stroop**	**WMT**	**Stroop**
Total Proverbs	.89*	-.78 ns	.61 ns	.15 ns	.83***	-.68*
Concrete Proverbs	.83*	-.63 ns	.64 ns	.13 ns	.73**	-.42 ns
Abstract Proverbs	.89*	-.91*	.55 ns	-.43 ns	.82***	-.83***

**p < .05; **p < .01; *** p <.001; ns = non-significant.*

4.2.4 Discussion

Experiment 2 was designed to examine the performance of adolescents with TBI on a proverb comprehension task. There was no difference between the group in their understanding of proverbs. Examination of individual performance reveled that two of the six adolescents with TBI demonstrated impairment relative to a New Zealand normative sample, as well as age-matched controls. The two participants with the greatest impairment (AR and CV) also demonstrated significant impairment on the Figurative Language Comprehension subtest of the *TLC-E* (as reported in Chapter 3). Although the Figurative Language Comprehension subtest stimuli are idioms rather than proverbs, the test results were consistent with the results of the *PCT*.

An analysis of the errors made by the adolescents with TBI, revealed that the majority experienced greater difficulty with proverbs that were abstract as opposed to concrete. This is consistent with errors made by typically developing adolescents (Nippold & Haq, 1996). This suggests that adolescents with TBI do not differ qualitatively from typically developing adolescents in their understanding of proverbs, although quantitative differences may exist. One individual (CV) did not show the same pattern, however slight individual differences could be expected across a non head-injured sample as well.

Working memory was found to be related to comprehension of both concrete and abstract proverbs in adolescents with TBI. Although no significant differences existed between the two study groups on either task, there was a significant correlation between WMT and Proverb Comprehension. This would suggest that a reduced working memory capacity would constrain comprehension of figurative language, particularly when the figurative expressions are not highly familiar. The proverbs on the *PCT* were selected because they are not common and therefore understanding would not be facilitated through familiarity. However, in order to further understand the effects of familiarity on figurative language comprehension, particularly in adolescents with TBI, examination of expressions with various levels of familiarity would be valuable. In Chapter 5, the effects of differing levels of familiarity on an alternative type of figurative expression, idioms, is examined

CHAPTER 5: IDIOM COMPREHENSION IN YOUNG ADOLESCENTS

5.0 Introduction

Idioms are a type of figurative expression that can have both a literal and figurative meaning. The phrase "*skating on thin ice*" is an example of an idiom (Nippold, 1998). Idioms are frequently encountered within an education context, both in written form through academic textbooks and in spoken form through teachers' expressions (Lazar et al., 1989; Nippold, 1998; Nippold, 1990). The Figurative Language Comprehension subtest of the *TLC-E* (Wiig & Secord, 1989), which is comprised of idioms, has frequently been used to assess children and adolescents with TBI. As noted in Chapter 4, however, findings related to the idiom comprehension based on TLC-E performance are inconsistent (e.g Jordan & Murdoch, 1994; Towne & Entwhistle, 1996). Likewise, the examination of comprehension profiles in adolescents with TBI (described in Chapter 3) demonstrated variability in figurative language comprehension both across and within individuals. The experiments described in this chapter therefore aimed to provide further insights into idiom comprehension development in typically developing New Zealand adolescents and to further explore the idiom comprehension performance of adolescents with TBI .

Variability in performance for adolescents with TBI may be related to characteristics inherent to the idioms that either facilitate or constrain comprehension. As with proverbs, idiom comprehension is influenced by a number of factors including familiarity and transparency (Nippold & Rudzinski, 1993; Nippold & Taylor, 1995; Nippold, Taylor, & Baker, 1996). Familiarity is a measure of how frequently one has heard or read an expression, and transparency is a measure of how closely the literal and the nonliteral meanings of the expression compare. For example, the nonliteral meaning of the transparent idiom, *skating on thin ice*, to be in a dangerous situation, is a metaphorical extension of its literal meaning. In contrast, the nonliteral meaning of the opaque expression, *talk through* *one's hat*, to speak without knowing the facts, has little to do with its literal meaning. As demonstrated by previous research (e.g., Nippold & Rudzinski, 1993; Nippold & Taylor, 1995), the findings concerning familiarity support the "language experience" hypothesis of idiom learning (i.e., idioms are learned, in part, through meaningful exposure to idiom expressions). The findings concerning transparency support the "metasemantic" hypothesis, the view that idioms are also learned through efforts to infer the nonliteral meaning from the literal meaning, a process that is easier to execute when the expressions are transparent.

There is evidence that young people employ a variety of strategies to learn different types of idioms (Nippold & Taylor, 1995). This position is consistent with the information-processing hypothesis of Burgess and Chiarello (1996), who have argued that figurative expressions such as idioms are comprehended through a "dynamic interplay" of top-down pragmatic and bottom-up semantic processes.

If engaging pragmatic processes to assist in the comprehension of an idiom the individual may attend to the linguistic context in which the expression occurs. Semantic processes aid idiom comprehension, through the individual's understanding and focus on each word that makes up the expression, a process that is more profitable with transparent idioms (e.g. *keep a straight face*). It is likely that, when context clues are limited, the learner must rely more heavily on features of the idiom itself, and that when the idiom is opaque (i.e., the words in the idiom expression do not suggest the idiom meaning such as "*kick the bucket*"), the context must be scrutinized more carefully. Familiarity with the idiom may help to offset the disadvantages of limited context clues and high opacity. In addition, increased familiarity has been associated with increased automaticity of processing, hence resulting in fewer demands being made on working memory.

The aim of the present study was two-fold. The first aim (described in Experiment 1) was to investigate how young adolescents (12 years of age) without TBI gain an understanding of idioms. In particular, it was designed to examine the role of idiom familiarity in conjunction with individual differences in students' language-based academic abilities. Young adolescents were the focus of the study because they are in a stage of human development when the ability to interpret figurative expressions rapidly improves (Nippold et al., 1996; Nippold & Rudzinski, 1993; Nippold & Taylor, 1995). For example, Nippold and Taylor administered a 24-item multiple-choice task of idiom comprehension to three groups of typically achieving students: 11 year old, 14 year old, and 17 year old students mean accuracy scores for the three groups, respectively, were 58%, 75%, and 82%, indicating that the greatest amount of growth was observed when the 14 year old students were compared to the11 year old students. More gradual improvements were observed when the 14 year old students were compared to the older adolescents.

Early adolescence is also a stage characterized by wide individual differences in the ability to interpret idioms. In that same investigation, the young adolescents showed the most variance in performing the task, with individual accuracy scores ranging from 25% to 92%. These patterns of rapid growth combined with wide individual differences suggest that a careful examination of young adolescents could offer a rich opportunity for learning more about the processes involved in understanding idioms.

In the study reported in this chapter, young adolescents' understanding of idioms was examined in relation to the individual's prior exposure to the expressions. In previous studies that examined the role of prior exposure (e.g., Levorato & Cacciari, 1992; Nippold et al., 1996; Nippold & Rudzinski, 1993; Nippold & Taylor, 1995), the familiarity ratings of idioms were based on the judgments of groups of individuals other than the young people whose idiom understanding was being evaluated. In the present study, it was believed that having the students themselves rate the idioms for familiarity would more accurately reflect the role of prior exposure in relation to idiom understanding. The students' ability to understand the idioms in relation to their performance on two measures of academic achievement, reading comprehension and listening comprehension, was also examined. It was believed that an examination of these relationships could offer additional insight into the processes involved in understanding idioms.

Although prior research had established that idiom understanding was associated with reading comprehension (Nippold & Martin, 1989), the association with listening comprehension had not been investigated. It was predicted that listening comprehension, in addition to reading comprehension, would be associated with idiom understanding, because both are major sources of language-learning input for school-age children and adolescents (Choate & Rakes, 1987; Funk & Funk, 1989; Nippold, 1998; Perera, 1986). Students frequently encounter unknown words when reading difficult material but are able to learn the meanings of those words by attending to relevant clues in the context (Stemberg, 1987). This process of inferring the meanings of unfamiliar words from context can also occur when listening to complex discourse.

The second aim of the study (described in Experiment 2) was to examine idiom comprehension in adolescents with TBI and explore the relationship between self-rated estimates of idiom familiarity and understanding of the idioms. In addition, the relationship between idiom comprehension and working memory was examined. Idiom comprehension, particularly of low familiarity items, would be predicted to make large demands on working memory. The idiom would have to be stored while the individual elements of the idiom were analysed in relation to the context. Thus it is hypothesised that adolescents with TBI will have weaker understanding of idioms than age-matched controls and that working memory will be related to idiom comprehension.

5.1 Experiment 1

5.1.1 Participants

Fifty students (17 boys, 33 girls) having a mean age of 12;4 and an age range of 11;8-12; 11, participated in this study. The students were enrolled in Year 8 at a primary school in Christchurch, New Zealand, located in a neighbourhood of middle-income homes. All were native speakers of standard New Zealand English, and according to their teachers, none had any disorders of language, learning, hearing, or cognition, or were receiving special education services. The students were drawn from two different classrooms, and all who returned a signed parental consent form were asked to participate. Participation exceeded 90% in each classroom.

5.1.2 Procedures

The children were tested in large-group fashion in their classrooms at school. They were administered the Idiom Familiarity Task and the Idiom Comprehension Task by two of the investigators while their teacher remained in the classroom. To obtain an unbiased estimate of a child's exposure to idioms, the Idiom Familiarity Task, a measure of how frequently a student had heard or read each idiom, always preceded the Idiom Comprehension Task, which measured the child's understanding of those same expressions. In addition, Reading Comprehension and Listening Comprehension scores from a school-administered measure, the Progressive Achievement Tests (New Zealand Council for Educational Research, 1994), were examined.

5.1.3 Materials

Idiom Familiarity Task

This task consisted of a list of 12 English idioms presented in random order. Each was a 4-word verb phrase (e.g., *strike the right note, blow away the cobwebs, paper over the cracks*) that had been drawn from a variety of reference books on idioms (Boatner et al., 1975; Clark, 1990; Gulland & Hinds-Howell, 1986; Kirkpatrick & Schwartz, 1982). These particular idioms were selected because previous research had shown that they represented a wide range of familiarity levels, at least from an adult and adolescent perspective (Nippold & Rudzinski, 1993). In the present study, students were asked to indicate how often they had heard or read each idiom, using a 5- point Likert scale. The procedures were identical to those that had been employed in previous research (Nippold & Rudzinski, 1993) with the exception that a much smaller set of idioms was employed (12 rather than 100). To introduce the task, the examiner read the following information aloud while the students followed along in their test booklets:

> Idioms are expressions that have special meanings. For example, hold your tongue is an idiom that means to be quiet. We could say, "Peter was talking at the same time as his teacher. His teacher said, "Peter, hold your tongue." This means that the teacher wanted Peter to be quiet. Some idioms are common while others are rare. Common idioms are ones that we often hear people say or that we often read in books, magazines, or newspapers. For example, pull someone's leg is a common idiom that means to fool someone. Rare idioms are ones that we seldom, if ever, hear or read. For example, walk the chalk line is a rare idiom that means to behave exactly as one has been taught. Some idioms are neither common nor rare; these are expressions that we sometimes hear or read but not too often. For example, get someone's goat, which means to anger or annoy someone, is neither common nor rare. There are 12 idioms in your booklet. We would like to find out how familiar these idioms are to you. There are no right or wrong answers. We just want to know what you think. All you need to do is circle the number on the scale that tells us how familiar the idiom is to you.

Following this introduction, three practice idioms were presented that were written in the same style as the test idioms. The students were asked to indicate their own familiarity with each of the practice idioms by circling the number and associated descriptive term (e.g., 2 = several times) with which they most agreed. Following the practice idioms, they were asked to answer the test idioms in the same manner. For example, one of the test idioms was as follows:

> I have heard or read this idiom: G*o into one's shell:* 1 = many times, 2 = several times, 3 = a few times, 4 = once, 5 = never

Students were cooperative and appeared to have no difficulty understanding the task or the directions. All students completed the task in 10 minutes or less. A maximum score of 5 could be assigned to each idiom, for a total of 60 possible points.

Idiom Comprehension Task

This task examined the students' understanding of each of the 12 idioms they had just rated for familiarity. It was a written, multiple-choice task, where each idiom was presented in a brief story context. The stories focused on topics of interest to New Zealand youth (e.g., school, sports, work, friends, family). Each consisted of four sentences that provided contextual support for a nonliteral interpretation of the idiom but did not give away that meaning. In the final sentence, the idiom was spoken by a character in the story. The student was asked to select the best interpretation of the idiom from a set of four choices. The choices were written carefully so that only one was appropriate but the three foils were neither highly implausible nor easy to eliminate. The task was written at the third grade reading level (ages 8-9 years) (Fry, 1968). Before the task was administered to the young adolescents, it was subjected to a validity measure. The purpose of this was to verify that it was indeed necessary to interpret the idioms in order to answer the questions correctly. This was accomplished by administering the task to a group of adults (n = 44) who were attending an American university. This group had a mean age of 26 years (range = 20-47 years), and all were speakers of standard American English. Scheduling issues prevented administration of the validity measure to New Zealand adults. However, the use of Americans should not detract from the results because the task was written in a narrative genre that is commonly used in both dialects of English. The adults were tested in large group fashion in classrooms at the university. Half of them received the task in its complete form and half received it in an incomplete form, with the two versions randomly assigned. For the incomplete form, the fourth sentence containing the idiom was deleted from each problem, but the story context remained. Different prompts were used for the complete and incomplete forms. For the complete form, the prompt was, *"What does it mean to say (idiom)?"*. For the incomplete form, it was, *"This story is talking about what it means to:"* Each prompt was followed by the same set of four answer choices. The adults were asked to read each problem silently and to select the answer choice that offered the best interpretation of the idiom (complete form) or the story (incomplete form).

The adults who took the complete form obtained a mean raw score of 11.36 (95%) (SD = 0.73, range = 9-12). In contrast, those who took the incomplete form obtained a mean raw score of 3.73 (3 1 %) (SD = 1.58, range = 1-7). A one-way ANOVA yielded a statistically significant effect for group [F(t, 42) = 424.57, p <.00011, indicating that the complete form was easier than the incomplete form. This confirmed that the idioms were indeed necessary for university students to respond appropriately to the task and indicated that they would be unable to answer the questions simply by reading the stories and the answer choices. Had that been possible, the task would have been one of reading comprehension rather than of idiom comprehension. To introduce the task to the young adolescents, the examiner read aloud the following information while the students followed along in their test booklets:

> Your booklet contains 12 short stories. The stories are about young people and some situations in which they sometimes find themselves. Each story contains an idiom and asks a question about its meaning. There are four answer choices. Read each answer choice carefully. Then choose the best one. Choose the answer that you think best explains the meaning of the idiom. Draw a circle around the letter of your choice - A, B, C, or D.

Before beginning the test problems, a practice problem was presented that was written in the same style as the test problems. The investigator read the practice problem aloud and asked the class to call out the best answer. After confirming the best response, the investigator asked the students if they had any questions about the task or the procedures. After answering all questions, the investigator instructed the class to begin working on the test. As an example, one of the test problems was as follows:

> *During lunch, Kristin always ate by herself at her own table. One day she decided to eat with some other girls. When one of them laughed at her new shoes, Kristin got upset. One of the girls said, "Kristin went into her shell. "What does it mean to go into one's shell?*

A. to do, something unusual
B. to do something bold
C. to be sorry about something
D. to pull away from others

Students were reminded not to share answers with their neighbours and to attempt all problems. They were cooperative and appeared to understand the procedures. The investigators monitored the testing sessions to ensure that students remained quiet and worked independently. All students completed the task in 20 minutes or less. A total of 12 points could be earned.

Given that the Idiom Comprehension Task was an experimental tool designed for the present study, it was important to obtain an estimate of stability on the task. To accomplish this, the task was administered a second time to 23 of the students (7 boys, 16 girls) who were available 4 weeks following the first administration (with scores on the first administration used for the main experiment). The procedures employed for administering the task the second time were identical to those that had been used the first time. The test-retest measurement indicated adequate stability (Salvia & Ysseldyke, 1981). The 23 students obtained a mean raw score of 7.43 (SD = 2.54, range = 3- 12) on the first administration, and a mean of 7.52 (SD 2.64, range = 2-1 1) on the second. The correlation coefficient obtained between raw scores for the two administrations was statistically significant and strongly positive ($r = .76, p < .0001$).

<u>Academic Achievement</u>

The *Progressive Achievement Tests (PATS)* (New Zealand Council for Educational Research, 1994) had been administered by the school to all children one month before their participation in the present study. In New Zealand, these tests are administered annually to children ages 8 through 14 years to monitor their progress in school and to identify those in need of assistance to improve their academic skills.

The *PAT*s have undergone extensive psychometric scrutiny. Scores on two of the tests, Reading Comprehension and Listening Comprehension, were used in the present study. Both tests have adequate concurrent validity (Reading = .82; Listening = .82) and test-retest reliability (Reading = .90; Listening = .87).

The *PATs* are administered in the classroom in large group fashion. Reading Comprehension requires students to read passages of up to 300 words in length, written in styles such as descriptive, narrative, and expository. Each passage is followed by questions that tap factual and inferential comprehension. Factual questions require memory of information stated in the passage, whereas inferential questions require going beyond the facts to draw conclusions; predict events; or determine points of view, themes, or main ideas. Students read the problems silently and mark their responses in individual test booklets. The content, style, and procedures for Listening Comprehension are identical to Reading Comprehension with the exception that the teacher reads additional sets of passages aloud to the class, followed by the questions. Students mark their answers in test booklets. A total of 48 points can be earned on each test.

5.1.4 Results

Four independent t tests (with Bonferroni corrections for multiple t tests) were performed to compare the performance of boys and girls on every measure. No statistically significant differences were found, [Idiom Comprehension: $t(48) = -0.95, p > .01$; Idiom Familiarity: $t(48) = -1.78, p > .01$; Reading: $t(48) = 0.36, p > .01$; Listening: $t(48)$ 0.20, $p > .01$]. Therefore, the data for boys and girls were combined for all subsequent analyses. Table 5.1 reports the performance of the entire group of students on each of the four measures. To determine a possible relationship between Idiom Comprehension and each of the other measures, correlation coefficients were computed, using the total raw scores that each student had obtained on each measure. Statistically significant coefficients were obtained in every case [Idiom Familiarity: $r = -.51, p < .001$; Reading: $r = .60, p < .0001$; Listening: $r = .55, p < .0001$], results that were moderately strong (Schiavetti & Metz, 1997). To measure the amount of shared variance between Idiom Comprehension and each of the other measures, the Index of Determination was computed, yielding r^2 values of .26,.36, and .30, respectively, for Idiom Familiarity, Reading Comprehension, and Listening Comprehension. Thus, the amount of actual overlap between Idiom Comprehension and each of the measures was somewhat low (Schiavetti & Metz, 1997). A dependent t test, performed to compare Reading and Listening Comprehension, indicated that Reading was more difficult than Listening ($t = -5.62$, $p < .0001$). The magnitude of the difference between Reading and Listening, computed by Cohen's d, was large ($d = .84$) (Cohen, 1988).

Table 5.1. *Performance for all students (n = 50) on the experimental tasks.*

Task	**Mean**	**SD**	**Range**
Idiom Comprehension (12 possible)	8.36	2.54	3 – 12
Idiom Familiarity (60 possible)	44.44	7.29	28 – 59
Reading Comprehension (48 possible)	26.08	7.18	11 – 42
Listening Comprehension (48 possible)	31.70	6.16	16 – 43

Table 5.2. *Idioms listed in order of increasing difficulty for the students as a whole (n = 50), shown with their mean accuracy scores and familiarity ratings.*

	Mean Accuracy Score	**Mean Familiarity Rating**
Go around in circles	.98	2.90
Go into one's shell	.92	3.82
Breathe down someone's neck	.90	2.92
Skate on thin ice	.76	1.66
Strike the right note	.72	3.68
Cross swords with someone	.70	4.28

Talk through one's hat	.64	4.46
Hoe one's own row	.60	4.82
Put one's foot down	.54	2.82
Blow away the cobwebs	.54	3.66
Paper over the cracks	.54	4.88
Hold up one's end	.52	4.46

[a] A measure of how often the idiom has been heard or read before:

1 = many times, 2 = several times, 3 = a few times, 4 = once, 5 = never.

Table 5.2 lists the idioms in order of increasing difficulty, based on the students' performance on the Idiom Comprehension Task. The mean familiarity rating that had been assigned to each idiom is shown as well. This table indicates that easier idioms were generally more familiar to the students than harder ones. For example, *skating on thin ice,* an easier idiom, was rated as most familiar, and *paper over the cracks,* a harder one, was rated as least familiar.

Given the statistically significant correlation coefficient obtained between Idiom Comprehension and Idiom Familiarity, it was of interest to examine the relationship between students' comprehension of specific idioms and their familiarity ratings for those same expressions. Recall that a score of 0 or 1 could be earned for each idiom on the Idiom Comprehension Task, and that a rating of 1, 2, 3, 4, or 5 could be assigned to that expression on the Idiom Familiarity Task, with greater numbers indicating less familiarity. Using the frequencies with which each of those scores and ratings occurred, a 2 × 5 (Comprehension × Familiarity) contingency table (Table 5.3) was constructed, and a chi-square test was performed to examine the association between Idiom Comprehension and Idiom Familiarity.

The results were statistically significant [$\chi^2(4) = 30.43$, $p < .001$, further supporting the notion that familiar idioms were easier than unfamiliar ones. For example, Table 5.3 shows that, out of 600 total responses (12 idioms × 50 students), 76 received a 1 in familiarity, indicating that the idiom had been heard or read many times, and of those idioms, 63 (83%) had been understood.

Table 5.3. *Contingency tables reporting how frequently idioms were comprehended in relation to familiarity ratings, based on the performance of all 50 students.*

	Familiarity *					
Comprehension	**1**	**2**	**3**	**4**	**5**	**Total**
0	13	14	14	35	106	182
1	63	49	76	74	156	418
Total	76	63	90	109	262	600

** A measure of how often the idiom has been heard or read before:*

1 = many times, 2 = several times, 3 = a few times, 4 = once, 5 = never.

However, there were exceptions to this pattern where students sometimes understood the idiom but had never encountered it before. As shown in the same table, 262 of the total responses received a 5 in familiarity, indicating that the idiom had never been heard or read before. Nevertheless, 156 (60%) of those idioms were understood by this group of students.

The standard deviations and ranges reported in Table 5.1 indicate considerable variance in students' comprehension of the idioms. To learn more about these individual differences, their raw scores on the Idiom Comprehension Task were examined closely. This analysis revealed that out of 50 students, 12 performed more than one standard deviation above the mean, earning raw scores of 11 or 12 ("good comprehenders"), and that another 12 performed more than one standard deviation below the mean, earning raw scores between 3 and 6 ("poor comprehenders"). The performance of these subgroups representing the extremes of good and poor idiom comprehension was compared on every measure, with their raw scores reported in Table 5.4.

Table 5. 4. Performance on the experimental measures for subgroups representing good and poor comprehension of idioms (n = 12 per subgroup).

	Good Comprehenders	Poor Comprehenders
Idiom Comprehension (12 possible) *		
M	11.50	4.83
SD	0.52	1.11
Range	11-12	3-6
Idiom Familiarity (60 possible) *		
M	40.08	50.17
SD	4.94	5.59
Range	36-52	38-59
Reading Comprehension (48 possible) *		
M	31.50	19.17
SD	5.63	3.97
Range	21-42	11-26
Listening Comprehension (48 possible) *		
M	36.58	28.00
SD	5.65	3.77
Range	24-43	21-34

* Significant at $p < .0002$

Four independent *t* tests (with Bonferroni corrections for multiple *t* tests) yielded statistically significant differences in every case [Idiom Comprehension: t (22) = 18.76, $p <$ .0001; Idiom Familiarity: $t(22) = -4.68$, $p < .0001$; Reading: $t(22) = 6.20$, $p < .0001$; Listening: $t(22) = 4.38$, $p < .0002$]. Cohen's *d*, used to determine the magnitude of the differences between subgroups, indicated large effect sizes in every case (Idiom Comprehension: $d = 1.90$; Idiom Familiarity: $d = 1.38$; Reading: $d = 1.56$; Listening: d 1.34) (Cohen, 1988). Consistent with the larger group results, dependent *t* tests indicated that Reading Comprehension was more difficult than Listening Comprehension for each subgroup (good comprehenders: $t = -5.36$, $p < .0002$; poor comprehenders: $t = -5.80$, $p <$ .0001), a pattern shown graphically in Figure 1. In each case, the magnitude of the difference between Reading and Listening, computed by Cohen's *d*, was large (good comprehenders: d .90; poor comprehenders: $d = 2.28$) (Cohen, 1988).

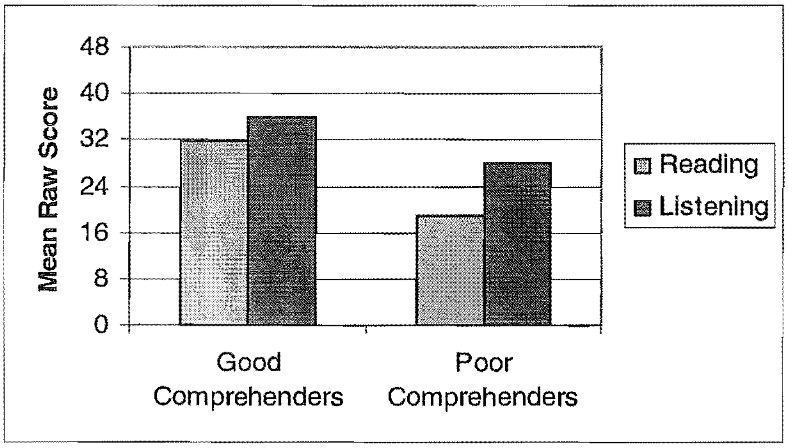

Figure 5.1. *Graph showing the performance of good and poor idiom comprehenders on the Reading Comprehension and Listening Comprehension sections of the Progressive Achievement Tests (New Zealand Council for Educational Research, 1994)*

To examine the relationship of Idiom Comprehension to Idiom Familiarity for these two subgroups, contingency tables (Table 5.5) were constructed using the frequencies with which each score (0 or 1) and rating (1-5) occurred for each subgroup. Although the resulting cell sizes were too small to perform valid chi-square tests (SAS Institute, 1996), it is informative nonetheless to examine the response patterns of the two subgroups. Table 5.5 indicates that, for the good comprehenders, out of 144 total responses (12 idioms × 12 students), 27 received a 1 in familiarity, and all 27 (100%) of those idioms were understood; at the other end of the continuum, 47 received a 5 in familiarity, yet 44 (94%) idioms were understood. In contrast, for the poor comprehenders, 10 responses received a 1 in familiarity, but only 5 (50%) of those idioms were understood, and out of 86 that received a 5 in familiarity, only 34 (40%) were understood.

Table 5.5. Contingency tables reporting how frequently idioms were comprehended in relation to familiarity ratings based on the performance of subgroups of good and poor idiom comprehenders (n = 12 per subgroups).

	Familiarity Rating*					
Comprehension	**1**	**2**	**3**	**4**	**5**	**Total**
	Good Comprehenders					
0	0	1	1	1	3	6
1	27	18	25	24	44	138
Total	27	19	26	25	47	144

	Poor Comprehenders					
0	5	6	4	19	52	86
1	5	4	7	8	34	58
Total	10	10	11	27	86	144

*A measure of how often the idiom has been heard or read before: 1 = many times, 2 = several times, 3 = a few times, 4 = once, 5 = never.

5.1.5 Discussion

The present study indicates that idiom understanding in young adolescents is associated with their own familiarity with the expressions and with their language-based academic skills in reading and listening comprehension. The findings regarding familiarity are consistent with previous research (e.g., Nippold & Rudzinski, 1993) but provide stronger evidence for it, because the students themselves rated their own prior exposure to the idioms they were later asked to interpret. The findings regarding academic achievement are consistent with previous research as well (e.g., Nippold & Martin, 1989), but extend the association to listening comprehension. It is reasonable to find that idiom understanding is associated with reading and listening comprehension, because both are major sources of language-learning input for school-age children and adolescents (Choate & Rakes, 1987; Funk & Funk, 1989; Nippold, 1998; Perera, 1986). This finding is also consistent with the frequent occurrence of idioms in spoken and written communication (Boatner et al., 1975; Kerbel & Grunwell, 1997; Lazar et al., 1989; Nippold, 1990). Thus, it is not surprising that students with stronger listening and reading skills are more proficient at interpreting idioms. However, the results must be interpreted cautiously, because the amount of shared variance between idiom understanding and each of the other measures was somewhat low, suggesting that other factors not examined in this study should be considered as well. For example, idiom transparency is also associated with idiom understanding in children and adolescents (Gibbs, 1987, 199 1; Nippold & Rudzinski, 1993; Nippold & Taylor, 1995).

The most novel contribution of the present study concerns the individual differences that were revealed by comparing subgroups of good and poor idiom comprehenders. It is helpful to consider some key differences between good and poor comprehenders of idioms. As shown by the present study, good comprehenders reported having had more exposure to idioms, and their performances on standardised achievement tests indicated that they also had stronger skills in reading and listening comprehension. In cases where good comprehenders were very familiar with specific idioms, they understood those expressions with 100% accuracy (Table 5.5). Perhaps their superior ability to comprehend what they read and hear has enabled them to take advantage of the exposure they have had to idioms in the ambient language. It is interesting, however, that even when good comprehenders were unfamiliar with specific idioms they still were able to interpret them with a high level of accuracy (94%). This suggests that they were able to benefit from context clues surrounding the idioms to discern meaning. In contrast, poor comprehenders reported having had less exposure to idioms, and their performance on standardised achievement tests indicated that they also had weaker skills in reading and listening comprehension. Importantly, even when poor comprehenders were very familiar with specific idioms, they still had difficulty interpreting them (accuracy = 50%), suggesting that they were less able to benefit from prior exposure. Although prior exposure to idioms may facilitate the learning process, it is likely that for some students this is not sufficient to ensure that the expressions will be understood.

The reasons for the good comprehenders' ability to analyse idioms they had not been previously exposed to and the poor comprehenders' inability do the same can be explained, in part, be a model of working memory. Idiom comprehension involves complex processing (Burgess & Chiarello, 1996). While a child is engaged in those processes, the products of those processes, the idioms themselves, and response options would have to be stored, hence making large demands on working memory. Poor comprehenders would be predicted to have fewer working memory resources than good comprehenders and therefore would be unable to process and store the idiom for comprehension. If adolescents with TBI demonstrate difficulties understanding idioms, then it would be expected that working memory would also be reduced. This is explored in experiment 2.

5.2 Experiment 2

5.2.1 Participants

The same twelve participants who took part in the proverb comprehension study engaged in the experiment. Demographic characteristics of the participants with TBI are reported in Chapter 3.

5.2.2 Procedures

The participants were assessed individually either at home or at school. Four measures were administered: Working Memory Span (Tompkins et al., 1994), Idiom Familiarity, Idiom Comprehension and the Stroop Test. Students completed the Working Memory span task (Tompkins et al., 1994) followed by the Idiom Familiarity and Idiom Comprehension Task. Upon completion of the Idiom Comprehension Task, the Stroop Test was administered. It took students approximately 30 minutes to finish the four tasks. Administration procedures for the Working Memory span task (Tompkins et al., 1994) and the Stroop Test were described in Chapter 4. The Idiom Familiarity and Idiom Comprehension Task were administered according to the instructions outlined in Experiment 1, with the exception that all stimulus items were heard as well as read. As listening comprehension is of interest, it was important for the participants to have heard the items. It was particularly important for participants with poor literacy skills to hear the items. One repetition of the entire stimulus (question and response choices) was allowed.

5.2.3 Results

The performance of the experimental group and the control group is reported in Table 5.6. Independent t-tests were carried out to compare the performance of the adolescents with TBI to the control group. No significant difference was found between the groups on any of the measures. To determine a possible relationship between Idiom Comprehension and each of the other measures for the experimental group, correlation coefficients were computed using the total raw scores that each student obtained on each measure. A negative correlation was found between Idiom Comprehension and Familiarity for the age-matched controls (r = -.54), however it was not significant (p = .24). No other correlations were noted, however when the two experimental groups were combined, the correlations between Idiom Comprehension and working memory, as measured by the WMT, approached significance (r = .52, p = .08)

Table 5.6. *Performance for all adolescents with TBI (n = 6) and age-matched controls (n=6) on the experimental tasks.*

	Adolescents with TBI			**Age-matched controls**		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**
Idiom Comprehension (12 possible)	9.33	1.51	7-11	10.00	2.28	6-10.5
Idiom Familiarity (60 possible)	44.83	7.68	34-55	36.67	9.6	22-50
Working Memory Task (42 possible)	28.00	8.81	15-37	32.80	4.09	28-37
Stroop Task (measured in seconds; Trial 1-Trial 2)	95.83	60.51	40-214	56.00	12.98	43-74

5.2.4 Discussion

The results of Experiment 2 were unexpected as no differences were found between adolescents with TBI and age-matched controls on measures of idiom comprehension or idiom familiarity. It was expected that individuals with TBI, particularly those who had reported difficulties with literacy, would present with lower familiarity and idiom comprehension scores than age-matched controls. In addition, a relationship between working memory and idiom comprehension was expected, but was not evident in the current results.

One possible explanation for the absence of a significant result when comparing comprehension and familiarity in adolescents with TBI versus age-matched controls is the small sample size and the low number of stimulus items. A greater number of stimulus items would have provided more opportunity for differences to emerge.

The lack of evidence of a relationship between idiom comprehension and familiarity is also inconsistent with previous studies (Nippold & Rudzinski, 1993.) and with the results in Experiment 1. A moderate negative correlation was noted for the age- matched controls however it was not significant. When the scores of the group with TBI and the age-matched controls were combined, no correlation was noted. The non-significant correlation for the age-matched controls may be due to the small sample size. For the adolescents with TBI, there was no trend to suggest that familiarity was related to idiom comprehension. It is possible, that adolescents with TBI are not as proficient at estimating how often they have seen or heard an idiom as the age-matched controls.

Working memory was not found to be related to idiom comprehension in either individuals with TBI or their age-matched peers. When the groups were combined however, the moderate correlation (Cohen, 1988) approached significance. Besides the small sample size, an alternative explanation for the result relates to how sensitive a forced-choice idiom comprehension task is to working memory. In order to identify differences in individuals' working memory capacities, the task has to be sufficiently challenging so that working memory resources are stressed and that only those with sufficient working memory resources are able to complete the task. If a task is not complex enough to extend the working memory resources, it will not be sensitive to differences in working memory capacity (Swanson, 1996). The forced-choice idiom task may not have been challenging enough to extend working memory resources, particularly for the older adolescents in the study. When determining the relationship between working memory and idiom comprehension, it may be more informative to use a response mode such as explanation, as idiom explanation has been found to be more challenging than for adolescents than forced-choice response (Nippold, 1998; Nippold & Taylor, 1995).

This study was designed to determine if there was a difference between adolescents with TBI and their age-matched peers and whether factors such as familiarity and working memory influence comprehension. No differences were noted however further research is warranted as the results suggest a trend toward a relationship between working memory and idiom comprehension, however larger sample sizes are needed. It is possible the task did not have sufficient processing and storage demands to constrain the working memory system. One way to increase the working memory demands is to increase the storage load. By manipulating the storage load, the effects of working memory on comprehension can be clearly measured. In the next study, working memory load is varied in order to examine another high-level language skill that has been found to be impaired in TBI, inference comprehension.

CHAPTER 6: INFERENCE COMPREHENSION IN ADOLESCENTS WITH TBI

6.0 Introduction

The ability to understand inferences (i.e., information that is implied by a speaker or writer rather than information that is explicitly stated) continues to develop during the adolescent years (Letts & Leionen, 2000). Comprehension of inferences is critical to an adolescent's social and academic success as inferences occur frequently in daily language use, as well as in classroom discourse. Research has demonstrated that at a group level, adolescents with TBI show impaired comprehension of inferences (Dennis & Barnes, 1990, 2000; Hinchliffe et al., 1998; Jordan & Murdoch, 1994). However, performance variability is evident in that some researchers have failed to find a significant difference between inference comprehension in children with TBI and inference comprehension in age-matched controls (e.g. Jordan et al., 1996). The language comprehension profiles of six adolescents who suffered TBI during childhood, reported in Chapter 3, also demonstrated performance variability in the population sample. Inference comprehension performance was severely impaired in three participants, but others demonstrated little difficulty on the inference tasks.

The nature of variability in the comprehension of inferences in adolescent with TBI has not previously been investigated. Although factors such as severity of brain injury may contribute to variability between individuals, within task variability is less easily explained. Rather, an examination of the stimulus factors that constrain and facilitate comprehension of inferences may provide clearer insights in to the comprehension difficulties that adolescent with TBI encounter. The purpose of the study reported in this chapter is to manipulate variables that either constrain or manipulate working memory and comprehension of inferences. The primary variable to be manipulated in this study is text distance. Text distance refers to the length of time an individual must store information over the distance of a text. With regard to inference comprehension, text distance refers to the amount of time between an inference being introduced, and when comprehension of the inference is assessed. By increasing text distance, storage demands are increased (Daneman & Carpenter, 1980; Lehman-Blake & Tompkins, 2001; Yuill et al., 1989), and fewer working memory resources will be available for processing the inference.

Text distance is one factor that constrains working memory and influences comprehension, however working memory involves both storage and processing. If the processing demands involved in the inference are minimal, then an increase in storage demands will have little effect on comprehension. When examining inference understanding in adolescents with TBI from a paradigm of working memory, therefore, it is essential to consider both the processing and storage demands of the task.

The processing demands involved in comprehending an inference task depend on the type of inference. There are numerous varieties of inferences described in the literature such as idiomatic, pragmatic, and thematic inferences (Letts & Leionen, 2000). Recently, researchers have begun to classify inferences based on the processing resources required to interpret the inference (McKoon & Ratcliffe, 1992; Swinney & Osterhout, 1990). According to a processing perspective of inference comprehension, inferences can be classified into minimal inferences and elaborative inferences. Minimal inferences are those that occur immediately or automatically, require few processing resources, and are independent of world knowledge. An example of a minimal inference is pronoun referencing (e.g. *The girl went to the shop. She bought some bread.*). Elaborative inferences are those that are controlled, strategic, slower and take greater processing resources (McKoon & Ratcliffe, 1992; Swinney & Osterhout, 1990). An example of an elaborative inference is a predictive inference. Predictive inferences involve listening to linguistic information and predicting the outcome based on the integration of context and available linguistic information. Because of the increased processing demands in these types of inferences, the comprehension of elaborative inferences may be more susceptible to impairment following a traumatic brain injury.

In addition to inference type and text distance, other factors that can facilitate or constrain inference comprehension should also be considered when assessing adolescents with TBI. Factors that may lessen or increase processing demands include:

1. Contextual bias: This refers to how likely a certain inference is, based on the context. For contextual bias, the stronger the context points to a particular inference, the more likely it is to be understood (McKoon & Ratcliffe, 1992).
2. Familiarity: Refers to how familiar the listener is with the lexical and contextual content of the inference. McKoon & Ratcliffe (1990) demonstrated that well-known information based on semantic associations such as "chair-sit" are encoded as quickly as anaphoric referents. Familiarity with the context (i.e. domain knowledge) was also shown to influence the speed and ease of inference comprehension (Yekovich, Walker, Ogle, & Thompson, 1990).

These factors are important to consider when evaluating inference comprehension in adolescents with TBI as they may help explain the performance variability evident in this population. Through manipulating the stimulus factors that constrain and facilitate comprehension and exploring the demands those factors place on working memory a deeper understanding of the abilities of adolescents with TBI to comprehend inferences may be gained.

The present study was designed to examine whether adolescents with TBI differ from a non-injured control group in their ability to make one type of elaborative inference, namely predictive inferences. Consideration is given in this study to factors that may influence inference comprehension and in particular the effect of increased storage load on comprehension performance is examined. If a "high-level language" hypothesis is accepted, it is predicted that adolescents with TBI will present with difficulties understanding inferences regardless of the working memory storage demands of the task. If a working memory hypothesis is accepted, it is predicted that adolescents with TBI show significant impairment on items with large storage demands, but will not differ from a control group on items with minimal storage demands.

6.1 Methods

6.1.1 Participants

The 12 adolescents who participated in Study 1(see Chapter 3) were engaged in this experiment. Six of the participants suffered TBI during childhood and 6 were age-matched peers without TBI. The participants ranged in age from 12 to 17 years and descriptive characteristics are reported in Chapter 3.

6.1.2 Design

The study was designed to manipulate task and response variables in order to constrain or facilitate working memory in the comprehension of the inference. Table 6.1 depicts the study design.

Table 6.1. Manipulation of Stimuli and Response Variable and the Effects on Working Memory

	Experimental Task Constraints on Working Memory		
Stimuli	Predictive inferences	Increases elaboration Decreases automaticity	Constrains WM
	Moving predicting sentence	Increases storage demands by increasing text distance	Constrains WM
Response	Explanation task	Off-line task	Constrains WM

WM = Working Memory

6.1.3 Procedures

Two working memory tasks were administered: Tompkins et al.'s (1994) Working Memory task, and the Stroop test. In addition to the working memory tasks, an inference comprehension task that evaluated understanding of predictive inferences was administered. The inference comprehension task was adapted from Lehman-Blake & Tompkins (2001) (See Appendix D). The inference comprehension task consisted of seven short stories describing common events (e.g. cleaning house). Three conditions existed for each story: a Distant condition, a Recent condition and a Control condition. All stories consisted of four sentences. In the recent condition, the first three sentences created the setting and the fourth, the predictive sentence, inferred a specific outcome. In the distant condition, the predictive sentence was placed early in the story (in the second position) so that there would be greater difference between the time the inference would be expected to occur and the response. Thus in the Distant condition, individuals would have to store the inference over a longer duration than in the recent condition. The design allowed for evaluation of the effect of recency of mention on an individual's ability to understand an inference (Lehman-Blake & Tompkins, 2001). The stories in the Control condition also contained four sentences but there was no predictive sentence. Instead, factual information about the outcome was presented. An example of the stimuli is as follows:

Recent Condition:

1. Jill had spent the day organizing her new desk. (Setting)
2. She wanted to let her brother know about her promotion. (Setting)
3. Jill knew he would be happy for her. (Setting)
4. She took out a piece of paper and a pen. (Predictive)

Distant Condition:

1. Jill had spent the day organizing her new desk. (Setting)
2. She took out a piece of paper and a pen. (Predictive)
3. She wanted to let her brother know about her promotion. (Setting)
4. Jill knew he would be happy for her. (Setting)

Control Condition:

1. Jill had spent the day organizing her new desk. (Setting)
2. She wanted to let her brother know about her promotion. (Setting)
3. Jill knew he would be happy for her. (Setting)
4. Jill called her brother and told him all about her new position.

Seven filler stories were also included in the task. The filler stories varied in length from two to five sentences. The filler stories did not contain predictive inferences.

The control and distant condition stories were all presented before the recent condition stories. The stimuli presentation order was determined after piloting the task with adults with traumatic brain injury. When the Recent Condition was presented before the Distant Condition, the participants in the pilot study appeared to remember the answer. whereas when the Distant Condition was presented first, they could not rely on recall. The filler stories were presented intermittently among all conditions. The stories were read at a normal speaking rate by the same examiner. The participants listened to each story. They were not permitted to read the story however. Following presentation of each story, a comprehension question was asked. The participants were asked what they thought was going to happen or what had happened and their answer was transcribed. Testing took place in a quiet room at the participant's home or school and sessions lasted approximately 20 minutes.

6.2 Results

6.2.1 Statistical Analysis

To evaluate the effects of text distance on adolescents with and without TBI, a two-way analysis of variance was calculated. Significant main effects were found for: Group, $F(1, 10) = 12.25$, $p = .002$, with adolescents with TBI performing more poorly than age-matched controls; and, Condition, $F(2, 10) = 31.06$, $p < .001$ with all participants performing more poorly in the Distant Condition. A significant Group x Condition interaction $F(2, 10) = 3.53$, $p = .042$, indicated a larger effect for the Distant Condition for the adolescents with TBI. The performance of the adolescents with TBI and the age-matched controls is summarized in Table 6.2.

Table 6.2: Group performance on inference comprehension task under differing conditions

	Adolescent TBI			**Age Matched Control**		
	Distant	Recent	Control	Distant	Recent	Control
Mean	3.50	6.00	6.67	5.67	6.67	6.83
SD	1.76	1.10	0.52	1.03	0.52	0.41
Range	1-6	4-7	6-7	4-7	6-7	6-7

TBI = Traumatic Brain Injury

6.2.2 *Qualitative Analysis*

Individual Performance

Examination of individual performance revealed that all participants demonstrated superior performance on the Recent Condition versus the Distant Condition. The two participants with TBI, with the lowest scores, AR and CV, also had the weakest overall comprehension profiles (described in Chapter 3). AR's errors in the Distant Condition appeared primarily to reflect difficulty remembering the stimulus sequence. AR reported forgetting what the examiner said but would sometimes guess a response based on world knowledge. An example of this is as follows:

1. Tim set out his jacket and his cap.
2. He put his rod in the car and drove to the lake.
3. He had been looking forward to this trip for months.
4. Tim had been busy at work and wanted some time alone.

Examiner: "What was Tim going to do?"

AR's response: "Relax and take it easy."

In the recent and control condition, AR answered the question correctly. Two of AR's errors were of a different nature. In one item, the error appeared to be a word-retrieval error. For instance, she said "Cleaned with a broom" versus "Swept". The answer was considered incorrect, as broom had been explicitly mentioned; therefore an inference had not taken place. It may have been however, that she could not formulate the correct word. The second error appeared to result from AR making an incorrect inference and unable to suppress the inference. AR heard the following passage:

1. Mary was almost finished with her Christmas presents.
2. She picked up a needle and thread and began to work.
3. She had already made a beautiful scarf for her father.
4. Mary also wanted to give her sister a special gift.

The inference from the predictive sentence (#2) was "sew", however AR responded with "knit". Knitting may be more highly associated with making a scarf than sewing and therefore overrode the inference created by "needle and thread". AR made the same error on the Recent Condition and on the Control condition. In the Control condition it is clearly stated that Mary went out and purchased a special gift, however could not seem to suppress the "knitting" inference and so inferred that Mary had knit a gift for her sister.

Like AR, CV's errors seemed to result from forgetting the predictive statement. He either responded with "I don't remember" or he made a prediction based on his world knowledge. Interestingly CV also had difficulty with the "Sew" inference and the "Sweep" inference. CV could not recall what happened in the Distant condition for either story. For the recent condition however, he selected "knit" instead of "sew" for Item 6, and he also said "Cleaned with a broom" versus "Sweep" for Item 7. His errors in the Distant condition were likely due to storage problems but his errors in the Recent condition may have been due to word finding difficulties or making an incorrect inference.

Participants 2 and 6, AH and SC made three errors on the Distant Condition. Two of the errors appeared to be due to difficulties storing the predictive sentence, while the third error occurred on Item 6 where both AH and SC also said "knit" for "sew". Participant 3 (RH) had two errors on the Distant condition; including replying "knit" for "sew". RH made the same error on the Recent Condition. Participant 5 (JW) had only one error in the Distant condition. He erred on item 7 where he predicted that the character "Cleaned the broom." versus "Swept". The same error was made in the Recent condition.

Analysis of performance overall revealed that adolescents with TBI can make inferences under optimum conditions such as highly predictive situations and when there are few storage demands (recency of mention). Even when errors were made, most inferences were plausible. Analysis of the errors revealed that although many errors appeared related to storage difficulties, certain items were more difficult than others. An examination of the specific items is therefore warranted.

Item Analysis

Items with a high error rate for adolescents with TBI were items 3, 6, and 7 and items 6 and 7 for participants in the age-matched control group. Items 3 and 6 may have elicited an alternative inference to the one intended. Item 3 was intended to elicit "rain"; however in some instances it elicited "wind". For item 6, "knit" was selected instead of "sew" for many of the participants. It is likely the two inferences that were made were stronger than the intended inference, perhaps due to familiarity and hence could not be suppressed by the adolescents with TBI. Item 7 was also in error for most participants and two of the adolescents with TBI appeared to have difficulty retrieving the correct word in their response to this item.

Additional factors that may have facilitated inference comprehension for the adolescents with TBI are the strength of the predicted outcome, and the semantic associations that may have been made regardless of additional information. Lehman-Blake and Tompkins (2001) suggested that adults with Right Hemisphere Disorder may have understood the inferences in the Recent condition because they strongly predicted a specific outcome. The same principle could apply for the adolescents with TBI. Alternatively, strong semantic associations may have facilitated comprehension. Five of the seven stimulus items contained instrument inferences. Instrument inferences are those whereby an action is inferred by an object (e.g. broom-sweep). Although instrument inferences are not generated automatically (Dosher & Corbett, 1987), they may have strong semantic associations, which are generated automatically. Although it is difficult to control for semantic associations, they must be accounted for when considering results and creating future stimuli.

6.3 Discussion

The current study was designed to examine whether adolescents with TBI demonstrated impairment in comprehending predictive inferences, and to identify variables that may influence inference comprehension. The performance of adolescents with TBI differed from their peers without brain injury only when presented with inferences that required increased storage demands. Thus adolescents with TBI do not have general inference comprehension deficits. The findings support a working memory model of inference comprehension and call into question the high-level language hypothesis.

The results highlight the importance of controlling task conditions. Inference type, stimulus characteristics, and response mode need to be considered in evaluating performance on inference comprehension tasks. Failure to control for these factors may lead to broad interpretations of inference abilities of individuals with TBI. In the current study the manipulation of distance between the predictive sentence (when the utterance should be formed) and the measurement of the utterance affected comprehension. Comprehension may also have been influenced by the strength of the predicted outcome suggested by the stimuli (Lehman-Blake & Tompkins, 2001).

Response factors may have also influenced performance. It has been argued that on-line comprehension tasks may be the most pure method of evaluating comprehension. On-line comprehension tasks measure comprehension at the point in time that the inference is made (Lehman & Tompkins, 2000). Examples of on-line tasks are speeded lexical decision tasks or reading-time tasks. The current study used off-line tasks. Comprehension questions are a common type of off-line tasks. When such off-line tasks are used, it cannot be determined whether the inference occurred at presentation or when the comprehension question was asked (Lehman & Tompkins, 2000). In addition, off-line tasks may increase storage demands (Lehman & Tompkins, 2000), however they may also serve to facilitate the inference. There are advantages to off-line comprehension tasks as well. First, clinical evaluation typically uses off-line comprehension tasks. In addition, academic performance is evaluated using off-line tasks. Perhaps the most important contribution of off-line tasks is the ability to examine performance based on elicited responses. For adolescents with TBI, except when they reported that they could not remember what was said, responded with plausible inferences although incorrect (e.g. “knit” for “sew”). Individuals who made those errors were drawing upon world knowledge (e.g. making a scarf= knitting) rather than integrating world knowledge with the linguistic context (e.g. making a scarf + needle and thread = sewing). Inferences based on world-knowledge rather than linguistic context was the most common type of error. An exception to that was JW who demonstrated the opposite type of error. JW, who was reported to interpret information literally, relied primarily on the linguistic context with little attention to world knowledge. When he heard the passages where the woman took a broom out of the closet, he inferred that she would clean the broom, even though the typical a more typical scenario would be to sweep. JW corrected the error when given a forced-choice task. On-line tasks provide information as to when an inference is made, however it does not establish the quality of that inference. A combination of off-line and on-line tasks may best evaluate inference comprehension in natural tasks.

In addition to the factors that were controlled for, other aspects of the task may have facilitated or constrained comprehension for the adolescents with TBI. For instance, familiarity may affect an individual's comprehension. In addition, in this study, strong semantic associations in the stimulus items may have facilitated comprehension (e.g. pen/write) for some participants.

Reduced working memory capacity did appear to be related to adolescents' understanding of inferences in conditions with high processing and storage demands. Conversely, low working memory capacity was not related to comprehension of inferences when storage and processing demands were low. Further examination of inference comprehension is required however. Investigations involving different types of inferences, and using a variety of response tasks will improve understanding of inference comprehension in TBI. Continued examination of the variables that facilitate comprehension may guide clinical intervention.

CHAPTER 7: FINAL DISCUSSION

7.0 Introduction

The listening comprehension profiles of adolescents who suffered a traumatic brain injury during childhood were explored from a perspective of working memory and normal language development. Predictions regarding performance were drawn from the context of a working memory model of comprehension. Evidence from case studies and experimental investigations provided insight into the influence of working memory on performance in adolescents with TBI on listening comprehension tasks. The case studies and experiments were supported by investigations of normal language development that highlighted influencing variables in the performance of typically developing New Zealand adolescents. A brief overview of the methodology of each study is presented followed by a discussion of the findings in relation to one another. The findings, taken together, provide insights into the listening comprehension abilities of adolescents with TBI and the nature of the relationship between working memory and performance on listening comprehension tasks.

7.1 Overview of Methodology

7.1.1 Memory Performance In New Zealand Youth

The first study described in this thesis examined the memory performance of adolescents aged 12 to 15 years (N = 81), using a clinical memory measure (*WMS-III*). The WMS-III provides normative data for American individuals aged 16- 89 years and this study established normative estimates for a New Zealand population of young adolescents on a variety of memory measures. The *WMS-III* was selected as it is a commonly used clinical tool and offers the best available standardized measure of working memory, the area of memory that was of particular interest in relation to language comprehension. The findings of this study provided a foundation by which performance on listening comprehension tasks could be compared to performance on working memory tasks in New Zealand adolescents with TBI aged between 12 and 16 years.

7.1.2 Case Studies

Performance of adolescents with TBI on a battery of listening comprehension tasks was examined in relation to working memory. Six adolescents with TBI and six age-matched controls were administered a range of listening comprehension tasks that targeted vocabulary, syntax, figurative language, inference and discourse comprehension. In addition, the *WMS-III* was administered and performance on working memory as well as verbal memory measures was examined with reference to the New Zealand normative estimates established for these measures. The listening comprehension profiles for the individuals with TBI were examined and the relationship between working memory and performance on the listening comprehension tasks was considered. The influence of working memory demands of the tasks in explaining individual variability in listening comprehension performance was investigated.

7.1.3 Proverb Comprehension Study

Following examination on a battery of standardized language comprehension measures, the adolescents' understanding of one aspect of figurative language, proverb comprehension, was explored in more depth. The *Proverb Comprehension Task* (Nippold et al., 2000) was selected as it controls for familiarity, a factor found to influence working memory demands and therefore language comprehension. The task was administered to eighty typically developing New Zealand adolescents, aged 12 and 14 years, to examine performance of New Zealand adolescents on the task and to assess the psychometric characteristics of the task. In addition, the relationship of proverb comprehension to comprehension (reading and listening) was explored. After examining the performance of typically developing adolescents the *PCT*, was administered to six adolescents with TBI and six age-matched controls. In addition, two measures of working memory, the Stroop test and Tompkins et al.'s (1994) Working Memory Task were administered to evaluate the relationship between performance on working memory tasks and proverb comprehension.

7.1.4 Idiom Comprehension Study

The effect of familiarity on language comprehension performance was further explored with reference to the comprehension of idioms. Participants in this study were required to self rate the familiarity of a given idiom. The first part of the study established typically developing patterns. Fifty students, aged 12 years, were presented with 12 idioms and were asked to rate whether they had seen or heard the idiom several times, many time, a few times, once, or never. The same 12 idioms were then presented in a forced-choice comprehension task. The relationship between idiom familiarity and idiom comprehension for typically developing 12 year olds was examined. In addition the relationship between idiom comprehension and reading and listening comprehension was explored.

In the second stage of the study, the idiom familiarity and idiom comprehension tasks were administered to six adolescents with TBI and six age-matched controls. Differences between the two experimental groups in idiom comprehension and idiom familiarity were explored. In addition, the relationship between idiom comprehension, idiom familiarity and working memory, as measured by the Stroop test and Tompkins et al.'s (1994) Working Memory Task was analysed for both groups.

7.1.5 *Inference Comprehension Study*

In this experiment, variables known to constrain working memory and increase storage load, were manipulated to enable performance on an inference comprehension task under varying working memory demands to be directly assessed. The twelve adolescents (six with TBI and six age-matched controls) who participated in the previous studies were presented with 21 short stories. Fourteen stories with a predictive inference and seven control stories, which did not contain an inference (Control Condition), were presented to the adolescents. In half of the stories where an inference was required, the predictive sentence was presented early in the story (Distant Condition). The listener was required to store the inference until the end of the story when the comprehension question was presented. The increased storage demands were predicted to constrain working memory and decrease comprehension. The remaining inference stories reduced storage load by presenting the predictive utterance immediately before presenting the comprehension question (Recent Condition); hence, decreasing working memory demands. The influence of working memory on comprehension of inferences for adolescents with TBI was evaluated by comparing their performance age-matched peers across the three conditions.

7.1.6 *Summary of Studies*

The series of studies were designed to answer a general question about the listening comprehension abilities of adolescents with TBI and to understand the nature of their language deficits. In particular, the following questions were addressed:

1. How do the listening comprehension profiles of adolescents with TBI compare with the language comprehension profiles of non-impaired adolescents?
2. How does the performance of adolescents with TBI on higher-order language tasks such as figurative language comprehension and inference comprehension compare with typically developing adolescents?

3. What is the nature of the relationship between working memory and performance on listening comprehension tasks for adolescents with TBI?

It will be argued from the evidence gathered in the case studies and experiments that listening comprehension is impaired in adolescents with TBI and that the nature of the observed difficulties is related to working memory. The studies demonstrate that performance on listening comprehension tasks vary depending on the working memory demands of the tasks.

7.2 Listening Comprehension of Adolescents with TBI

Listening comprehension of adolescents with TBI was examined using a variety of research methods (case studies and experimental tasks) and across a variety of comparison groups. Performance of adolescents with TBI was examined in the context of normal language development, individual performance and using comparisons to age-matched controls.

Two primary differences were observed between the adolescents with TBI and the age-matched controls. First, individuals with TBI generally performed more poorly on listening comprehension tasks. For instance, examination of individual listening comprehension profiles in Chapter 3 revealed that the participants with TBI, with the exception of JW, scored below normal limits on at least one subtest of the test battery. As a group, the adolescents with TBI performed significantly more poorly than age-matched peers on the inference comprehension tasks.

The second major difference that was evident between adolescents with TBI and an age-matched control group was that individuals with TBI were more sensitive to working memory demands than their age-matched peers. For instance, a significant relationship was found between the Working Memory Task (Tompkins et al., 1994) and proverb comprehension for the individuals with TBI. In addition, adolescents with TBI demonstrated significantly reduced performance on an inference task when working memory demands were increased relative to the age-matched controls. Although no relationship was found between idiom comprehension and working memory, there was a trend toward significance for individuals with TBI.

In addition to comparing quantitative differences between adolescents with TBI and age-matched peers, qualitative differences in the patterns of performance between the two groups were evaluated. It is significant to note that the pattern of performance for the two groups appeared similar. For instance, when listening comprehension profiles of the two experimental groups were examined, both demonstrated variability across and within tasks. The variability patterns for both the adolescents with TBI and the control group supported a working memory model of language comprehension. That is, all individuals were influenced by working memory in that they tended to perform more poorly on tasks with high working memory demands. The outcome of that variability for adolescents with TBI was evidenced as impaired comprehension because they were operating within a constrained working memory system.

Similar patterns of performance were seen between the adolescents with TBI and data collected from a sample of typically developing adolescents. Adolescents made more errors on the abstract proverbs than the concrete proverbs, which was consistent with the normative data that was gathered. The adolescents with TBI differed from the normative sample of 12 year olds on the idiom comprehension task in that familiarity was not associated with comprehension, however a non-significant finding was also noted for the age-matched control group. The failure to find significant relationships between idiom familiarity and idiom comprehension may have been a factor of the small sample size.

The adolescents with TBI presented with a similar pattern of performance to the age-matched controls on the inference comprehension task. Both groups had a decrease in comprehension in the Distant Condition (which had an increased storage load) versus the Recent Condition. In addition, the types of errors made were similar across groups. Inference understanding involves integrating linguistic information with contextual information and/or real-world knowledge. In every case, even those inferences that were in error were plausible for both the individuals with TBI and the age-matched controls. The typical pattern of response, for both adolescent groups was to draw upon real-world knowledge when predicting the inference even though at times, the inference was incorrect because the linguistic information had not been stored and integrated. The following example from Participant 4 (CV) demonstrates this pattern of error:

Examiner: Joe set out his gloves and his coat.

He put his rod in the car and drove to the lake.(predictive sentence)

He had been looking forward to this trip for months.

Joe had been busy at work and wanted a weekend alone.

What do you think Joe was going to do while he was away?

CV: Relax and take it easy. Maybe read.

In this example, CV had not stored the linguistic information over the duration of the text but he drew on his world knowledge to propose a plausible but incorrect inference. When the same example was presented in the Recent Condition, CV responded correctly. One participant in the group of adolescents with TBI (JW) did not respond in the typical pattern. JW scored within average on all subtests of the language comprehension battery with his highest score achieved on the *PPVT-III* (97th percentile) and his lowest score achieved on the figurative language comprehension subtest of the *TLC-E*. During the inference comprehension task, JW attended to the linguistic information and was able to store inferences across text distance. He presented with one error on the inference comprehension task on both the Recent and Distant Conditions when he appeared to rely solely on the linguistic information without integrating real world knowledge. For example:

Examiner: Jane was cleaning house on Saturday.

She had already worked most of the day.

Now Jane had one more task to do.

She went to the closet and took out a broom. (predictive sentence)

What do you think Jane was about to do?

JW: Clean the broom.

Overall, however, performance of individuals with TBI was qualitatively similar to the performance of the age-matched controls, yet quantitatively more impaired.

Patterns of performance for individuals with TBI are consistent with a working memory model of language comprehension. The adolescents with TBI and their age-matched peers appeared to have different linguistic processing strengths and weaknesses. However these processes, within a constrained working memory system were likely to result in impaired comprehension. That is, an individual with a semantic processing weakness may perform relatively well on a simple semantic comprehension task but when processing demands (such as integrating context with lexical knowledge) and storage demands are increased, performance is compromised.

7.3 Working Memory as A Model of Listening Comprehension in Adolescents with TBI

The common paradigm for explaining communication difficulties in TBI is that there is a primary cognitive deficit that results in communication impairment. Hence, communication impairment in TBI is secondary to cognition. There are a number of problems with this paradigm. First, it artificially separates language from cognition. Language is one of a number of cognitive functions and although the separation of cognition into linguistic and non-linguistic functions is helpful for studying language, it does not represent the interplay between language and "non-linguistic" concepts such as working memory. The second major problem with the paradigm is that it assumes a hierarchy between non-linguistic and linguistic cognition. It has been demonstrated that language and cognition interact (Vygotsky, 1992). In adults with TBI, correlations were observed on tests of cognition and tests designed specifically to look at language (Hinchliffe et al., 1998). A model of working memory accounts for the interaction between cognition and language and explains differences in performance on listening comprehension tasks for individuals' with TBI.

Variability in performance among individuals with TBI has typically been attributed to differences in severity of injury, age at injury, and type of injury (Klonoff, Clark & Klonoff, 1995). Such influences may have had some affect on the observed differences in performance across the individuals in this study, but they cannot explain the variability in results across subtests. Rather, results of the studies presented in this thesis suggest variability across subtests may be best explained from a working memory perspective. Evidence of working memory influencing language comprehension performance was found in the following results:

1. Participants with TBI demonstrated better performance on standardized tests that were predicted to have fewer working memory demands. Examination of the results from the Case Studies (described in Chapter 3) revealed that all participants achieved higher scores on the *PPVT-III* (Dunn & Dunn, 1997), a test with very few working memory demands, than on tests of inference comprehension, figurative language, understanding of multiple meanings and discourse comprehension that have higher working memory demands.
2. Performance of adolescents with TBI on the experimental language tasks was influenced by the working memory demands of the task. Individuals with TBI performed more poorly on an inference comprehension task when working memory demands were high (Distant condition) versus when they were low (Recent condition) (Chapter 6). In addition, individuals with TBI had significantly impaired performance on the Distant condition compared to the control participants, whereas there was no difference in comprehension between the two groups on the Recent condition or Control condition. Hence, tasks that place demands on a constrained working memory system will be impaired, whereas when task demands do not exceed available working memory, comprehension is preserved.

If a theory of a general cognitive deficit for the language comprehension performance of individuals with TBI is accepted, a flat profile of listening comprehension would be expected. If a primary language deficit hypothesis is adopted, more consistent performance would be expected across tasks and perhaps a primary syntactic or a primary semantic deficit would be evident. One participant in the study, CV, did demonstrate a semantic deficit that appeared to be relatively isolated from working memory. Further exploration of the contribution of his semantic deficit and working memory to overall comprehension scores would be warranted. Other participants, however, presented with deficits that are best explained by a working memory theory of listening comprehension.. For instance, AR scored very poorly on tests of syntax and semantics, but had within average performance on a discourse passage. . Some participants had excellent performance when identifying words with only one meaning but had poor performance when identifying words with multiple meanings. Working memory provides a plausible explanation for these results and lends support to an interactive theory of language impairment in adolescents with TBI.

Theories of language comprehension drive both assessment and intervention practices. If a primary non-linguistic cognitive deficit is accepted for poor comprehension, then the clinical focus will be directed to the identification and treatment of factors such as attention and memory. If an interactive paradigm of language and working memory is accepted as a theory for language comprehension, then assessment of individuals suspected of impaired comprehension performance will focus on identifying factors that facilitate and constrain working memory. Further examination of the factors that influence working memory is obviously needed but viewing the listening comprehension deficits associated with TBI in terms of how individuals perform relative to working memory demands will have immediate ramifications for how speech-language therapists assess and treat individuals with TBI.

7.4 Alternative Hypotheses of the Linguistic Deficit in TBI

7.4.1 Developmental Hypothesis

The developmental model for explaining deficits following TBI predicts that linguistic skills that are continuing to develop, or are not established at the time the head injury occurs, will be more susceptible to impairment as children with TBI develop (Barnes, 1989; Ewing-Cobbs et al., 1987). This is particularly true for linguistic skills that are rapidly developing (Ewing-Cobbs et al., 1987). A developmental hypothesis of listening comprehension impairment in adolescents with TBI was not entirely supported by the findings of the studies in this thesis. Although two of the six adolescents with TBI presented with an area of weakness that was consistent with a rapid developing hypothesis (understanding of multiple meanings), the overall patterns of performance for the individuals with TBI were not consistent with a developmental hypothesis.

Normal language development must be considered when examining children and adolescents with TBI for a number of reasons. First, it is important to test those linguistic areas that are typically developed and utilized throughout adolescence. For instance, understanding of simple syntax may be sufficient for conversation or narrative production but may not be sufficient for producing expository discourse or other forms of discourse necessary for adequate academic functioning. From a working memory perspective, it is also important to assess the more complex linguistic skills that are developed in adolescence as a constrained working memory system will reveal impaired performance on complex linguistic tasks but not on simple linguistic tasks (Just & Carpenter, 1992).

Perhaps the most important contribution of the developmental literature to understanding language comprehension difficulties in adolescents with TBI is related to how information is understood and which factors facilitate comprehension in typically developing adolescents. The developmental hypotheses put forward by Barnes (1989) and Ewing-Cobbs (1987) focus on when linguistic skills develop but not on the quality of development. The work of Nippold and colleagues (e.g. Nippold & Haq, 1996; Nippold & Martin, 1989;Nippold & Rudzinski, 1993) has provided an immense contribution toward the understanding of factors, such as familiarity and transparency that facilitate comprehension. Awareness of facilitative factors can assist researchers in identifying whether individuals with TBI demonstrate the same patterns of performance as typically developing adolescents. It also has clinical implications in that factors that have been found to facilitate comprehension in typically developing adolescents may also facilitate comprehension in children and adolescents with TBI. Further investigations into the relationship between factors that facilitate comprehension and working memory are warranted to better understand comprehension in adolescents with and without TBI.

7.4.2 Higher-order Language Hypothesis

Higher-order language skills are defined as language tasks that are interactive, involve metalinguistic knowledge, and/or language involving syntactic/lexical manipulation (Hinchliffe et al. 1998, 2001). The hypothesis that higher order language skills are impaired in individuals with TBI (Hinchliffe, et al., 1998; Jordan et al., 1996) has provided direction for examining areas of language in children and adolescents with TBI such as figurative language and inference comprehension. The findings are partially supportive of a theory of "high level language" impairment. All participants showed some difficulties with those language skills described as high-level. One participant, JW, had within average scores on all tasks, but had relatively poor performance on the figurative language subtest.

There are several inherent problems with the "high-level language" concept for explaining the results reported in this thesis. First, the adolescents with TBI did not have an overall impairment with high-level language regardless of the severity of impairment. For instance, many of the participants were identified as moderately to severely impaired, however they were able to understand inferences under optimal conditions. A second problem with the concept of "high-level language impairment" refers to the terminology itself. The term "high-level language" implies a hierarchy of cognition with core linguistic skills being below higher-order skills in a hierarchy of processing. The type of language impairment in adolescents with TBI may be better described as difficulties with "integrative language skills" however even that has limitations when describing the type of impairment following TBI. Many of the adolescents who took part in this study were able to perform integrative tasks. An integrative task such as understanding an inference that is presented in a highly familiar context however may be very automatic. Conversely, an integrative task that is unfamiliar may involve strategic processing such as analyzing the various elements of the linguistic input. The language impairment following TBI may be better described as an impairment with comprehension of language involving strategic processing. Borrowing from McKoon & Ratcliffe's (1992) classification of inferences, it may be that language tasks vary on a continuum between relatively automatic to strategic or elaborative. Depending on the conditions in which strategic language processing takes place, performance will either be facilitated or constrained.

7.5 Limitations of the Study

Limitations in the study arose from variables related to the some of the tasks used to assess listening comprehension in adolescents with TBI. With regard to stimuli, no significant relationship between familiarity and comprehension for adolescents with TBI was evident in the idiom comprehension study, however the lack of an effect may have been related to the low number of stimulus items. An interaction between familiarity and comprehension was demonstrated using the same task for a group of typically developing adolescents, however the sample size was much larger.

Stimulus variables may also have influenced the results in the inference comprehension task. The stimuli were designed to assess understanding of predictive inferences, however it is possible that semantic associations were made in some of the items. Semantic associations are thought to occur automatically; hence the processing resources required for understanding the inference would not have been equivalent across stimuli.

Related to the inference comprehension task, one aspect of the task design that could be considered a weakness was the response mode used to evaluate understanding of the inference. The inference comprehension task was adapted from Lehman-Blake and

Tompkins (2000) who assessed inference understanding using an on-line comprehension task. On-line comprehension tasks refer to those that evaluate comprehension at the time it occurs. Examples of such tasks are lexical decision and semantic priming tasks. Off-line tasks are more commonly used and assess comprehension after it has taken place, often by asking a comprehension question. It has been argued that on-line comprehension is a more accurate measure of inference comprehension. It has been argued that inferences may not be made until a comprehension question is presented for instance (Lehman-Blake & Tompkins, 2000). Therefore inference understanding may not have occurred at the time the inference was presented. There is compelling evidence from studies using on-line comprehension tasks for assessing comprehension in individuals with brain damage (e.g. Kempler, Almor, & MacDonald, 1998; Shapiro, Swinney, & Borsky, 1998). However, valuable information was identified in this study during the off-line comprehension task that would not have emerged using on-line comprehension tasks. For instance, the adolescents with TBI at times made plausible inferences that were incorrect. Using on-line comprehension tasks, it would have been determined that individuals with TBI understood inferences but the nature of the inference made would not have been evident.

Finally, related to task limitations, it would have been of interest to include a standardized measure of syntactic and lexical ambiguity in the battery of listening comprehension subtests (Chapter 3). Syntactic and lexical ambiguity comprehension has been shown to be associated with working memory (MacDonald et al., 199?) and also has been reported to be impaired following TBI (Jordan et al., 1996). Unfortunately, the only standardized task available for this study was the Ambiguous Sentences subtest of the *TLC-E* (Wiig & Secord, 1992). The Ambiguous Sentences subtest was considered inappropriate for this study, as the response mode was an explanation task versus a comprehension task. In addition, the stimuli were presented out of context and so did not assess understanding of ambiguous sentences when context had to be considered for understanding to occur. The performance of adolescents with TBI on an ambiguous sentence task should be considered for future studies.

7.6 Clinical Implications

Evidence indicating that adolescents with TBI demonstrate listening comprehension impairment associated with working memory limitations, has implications for the way speech-language therapists assess and treat language impairment following TBI. Rather than assessment focusing primarily on identifying discrete impairments in linguistic areas such as syntax or semantics, evaluation would involve determining under what conditions comprehension is compromised or facilitated. Intervention would then focus on implementing strategies so that factors that facilitate comprehension would be incorporated into academic and social situations.

A second implication for assessment is that speech-language therapists and other professionals involved in assessment of adolescents with TBI will need to carefully evaluate the task demands of the assessment tools that are used and consider the conclusions that are being drawn from those assessments. For instance, assessments that involve tasks with high storage demands may be influencing performance. Therefore, an adolescent who demonstrates difficulty on the Making Inferences subtest of the *TLC-E*, may be able to understand inferences when less storage is required in the task. Likewise, an adolescent who demonstrates average understanding on a discourse comprehension task, may have difficulty understanding conversations in group situations as some working memory resources will be allocated for suppressing irrelevant information (Engle, 1996) leaving fewer working memory resources available for comprehending what is said.

It is a common complaint clinically, that standardized tests are not sensitive to the language deficits resulting from TBI (Hinchliffe et al., 1998), and that language deficits may not be evident from standardized testing but language difficulties exist in the natural environment. This phenomenon is easily explained by a working memory theory of language comprehension. Testing situations are quiet and take place in one-on-one where instructions are stated very clearly, and checked for understanding before any testing occurs. In daily life situations, it is likely that additional processing demands are being made such as suppressing irrelevant information and storing instructions while processing what is to be done. A useful task that could be integrated into a clinical setting would be to increase the external storage demands while individuals are engaged in language tasks and observe the effect on performance. This would assist the speech-language therapist and the individual in understanding the influence of increased memory demands on performance.

Acceptance of a working memory model of listening comprehension would also influence intervention goals for adolescents with TBI. Speech-language therapists could assist parents and teachers in understanding variability in performance that is evident in adolescents with TBI. The adolescents with TBI who participated in this thesis, all complained of academic difficulties but the schools were not always able to identify the problem. The teachers at RH's school noted that she appeared to be fine most of the time and could not understand why she had difficulties following instructions in tests and listening situations.

Intervention would also focus on establishing factors that facilitate working memory and improve comprehension. Factors that could be addressed in therapy would include: increasing familiarity with a task or elements of a task and decreasing external memory load. The importance of evaluating working memory demands when assessing and treating individuals with TBI is essential both for improving services to adolescents with TBI and for better understanding the effects TBI has on listening comprehension.

7.7 Future Research

The findings in this thesis have theoretical and practical implications for future research. At a theoretical level, further research into the nature of working memory is required. The adolescents with TBI who participated in this study performed relatively superior performance on a syntactic comprehension task in spite of large storage demands. It has been proposed that syntactic processing is relatively automatic and does not require extensive working memory resources for processing (e.g. Waters and Caplan, 1996). Further research into the automaticity of particular language functions would contribute to greater understanding of working memory influences on performance on various language tasks.

Greater understanding of factors that constrain and facilitate comprehension would have both theoretical and practical implications. Improved understanding of working memory constraints would be supported by further research into the affects of factors such as familiarity or time constraints in typically developing adolescents. Understanding of behaviour in a typically developing population is essential before understanding of behaviour that may be atypical is assessed.

At a practical level clinical research into the factors that facilitate comprehension in adolescents, as well as children and adults, with TBI would result in more effective treatment programs. It would be a logical assumption that if factors that constrained comprehension were removed, then comprehension would be facilitated however Turkstra & Holland found that decreasing the storage load did improve comprehension but allowing individuals with TBI extra time for responding did not facilitate comprehension.

Finally, the effects of reducing working memory demands on listening comprehension must be measured relative to performance in school and social settings. In order for working memory to be a useful tool for understanding and treating listening comprehension deficits in adolescents with TBI, it is essential to determine whether focusing on facilitating working memory has benefits to daily situations that are important to adolescent life.

7.8 Summary

The findings regarding listening comprehension in adolescents with TBI suggest that TBI results impaired comprehension in adolescents with TBI, but that performance on language tasks is influenced by the working memory demands of that task. The results of the studies should challenge researchers and clinicians to examine adolescents with TBI in terms of their performance on a variety of language tasks, as opposed to attempting to isolate specific deficits in the linguistic or cognitive system. That is, it is the interaction between core language skills (e.g. syntax or semantics (Hinchliffe et al., 1998), the processing demands of the task, and the storage demands of the task that all contribute to how individuals with TBI perform. Identification of factors that constrain and facilitate working memory and, more importantly, language comprehension in both individuals with and without TBI, will provide insights into new assessment and intervention techniques that better reflect the nature of the listening comprehension impairment in TBI and ensure children and adolescents with TBI are free from persistent language and academic difficulties through the school years and are able to develop their full potential in society.

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APPENDIX A

WMSIII - Scaled-Score Equivalents of Raw Scores for Primary Index Subtest Scores: Age 12

Scaled Score	LM I	Faces I	VPA I	Fam Pic I	Let Num	Spat Span
19	63-65	45	43-45	72-74	15	25
18	59-62	44	41-42	70-71	~	24
17	56-58	43	38-40	67-69	14	23
16	52-55	42	35-37	64-66	13	21-22
15	48-51	41	32-34	61-63	~	20
14	44-47	40	29-31	58-60	12	19
13	41-43	39	27-28	55-57	11	18
12	37-40	38	24-26	52-54	~	17
11	33-36	37	21-23	49-51	10	16
10	29-32	35-36	18-20	46-48	9	15
9	26-28	34	15-17	43-45	~	14
8	22-25	33	13-14	40-42	8	13
7	18-21	32	10-12	37-39	7	12
6	14-17	31	7-9	34-36	~	11
5	11-13	30	4-6	31-33	6	10
4	7-10	29	1-3	28-30	5	9
3	3-6	28	~	25-27	~	8
2	1-2	27	~	22-24	4	7
1	~	26	~	20-21	1-3	5-6

WMSIII - Scaled-Score Equivalents of Raw Scores for Primary Index Subtest Scores: Age 12 *(continued)*

Scaled Score	LM II	Faces II	VPA II	Fam Pic II	Aud Rec	Digit Span
19	40-41	46	~	~	60	22
18	38-39	45	~	~	58-59	21
17	35-37	44	~	~	57	20
16	33-34	43	~	64	56	19
15	30-32	42	~	61-63	54-55	18
14	28-29	41	~	58-60	53	17
13	26-27	40	8	55-57	51-52	16
12	23-25	39	~	52-54	50	15
11	21-22	38	7	49-51	49	14
10	18-20	37	6	46-48	47-48	13
9	16-17	35-36	~	44-45	46	12
8	14-15	34	5	41-43	44-45	11
7	11-13	33	4	38-40	43	10
6	9-10	32	~	35-37	41-42	9
5	6-8	31	3	32-34	40	8
4	4-5	30	2	29-31	39	7
3	2-3	29	~	26-28	37-38	6
2	1	28	1	23-25	36	5
1	~	27	~	21-22	34-35	~

WMS-III - Scaled-Score Equivalents of Raw Scores for Primary Index Subtest Scores: Age 13

Scaled Score	LM I	FACES I	VPA I	Fam Pic I	Let-Num	Spat Span	Spat Span Sqrt
19	69-71					24	
18	65-68	47-48				23	22
17	60-64	46			17	22	21
16	56-59	45		64	16	21	~
15	52-55	43-44	32-34	61-63	15	20	20
14	48-51	42	29-31	58-60	~	~	19
13	44-47	41	26-28	56-57	14	19	~
12	39-43	39-40	23-25	53-55	13	18	18
11	35-38	38	20-22	50-52	12	17	17
10	31-34	37	17-19	48-49	~	16	16
9	27-30	35-36	14-16	45-47	11	15	15
8	23-26	34	11-13	42-44	10	~	~
7	18-22	33	9-10	40-41	9	14	14
6	14-17	32	6-8	37-39	~	13	13
5	10-13	30-31	3-5	34-36	8	12	12
4	6-9	29	2	32-33	7	11	11
3	2-5	28	1	29-31	6	10	10
2	1	26-27		26-28	~	9	9
1		25		25	5	8	8

WMS-III - Scaled-Score Equivalents of Raw Scores for Primary Index Subtest Scores: Age 13 *(continued)*

Scaled Score	LM II	FACES II	VPA II	Fam Pic II	Fam Pic II Log10	Aud Rec	Digit Span
19	41-42						22
18	39-40				59		21
17	37-38				~		20
16	34-36	47-48		64	~	54	19
15	32-33	45-46		61-63	58	53	18
14	30-31	43-44		58-60	57	52	~
13	28-29	42	8	56-57	56	~	17
12	25-27	40-41	~	53-55	55	51	16
11	23-24	38-39	7	51-52	53-54	50	15
10	21-22	36-37	6	48-50	51-52	~	14
9	18-20	34-35	5	46-47	48-50	49	13
8	16-17	33	4	43-45	44-47	48	~
7	14-15	31-32	~	41-42	39-43	47	12
6	12-13	29-30	3	38-40	32-38	~	11
5	9-11	27-28	2	35-37	24-31	46	10
4	7-8	25-26	1	33-34	16-23	45	9
3	5-6	24		30-32	8-15	~	8
2	3-4	22-23		28-29	1-7	44	7
1	1-2	20-21		25-27		43	

WMSIII - Scaled-Score Equivalents of Raw Scores for Primary Index Subtest Scores: Age 14

Scaled Score	LM I	Faces I	VPA I	Fam Pic I	Let-Num	Spat Span
19	49-51	48		62-63	16	24
18	47-48	46-47		60-61	15	23
17	44-46	45		58-59	~	~
16	42-43	44		55-57	14	22
15	40-41	42-43	32	53-54	13	21
14	37-39	41	30-31	51-52	12	20
13	35-36	39-40	27-29	49-50	~	19
12	32-34	38	25-26	46-48	11	18
11	30-31	36-37	22-24	44-45	10	17
10	27-29	35	19-21	42-43	~	16
9	25-26	33-34	17-18	40-41	9	15
8	22-24	32	14-16	37-39	8	14
7	20-21	31	12-13	35-36	7	13
6	17-19	29-30	9-11	33-34	~	12
5	15-16	28	7-8	31-32	6	11
4	12-14	26-27	4-6	28-30	5	10
3	10-11	25	2-3	26-27	4	~
2	7-9	23-24	1	24-25	~	9
1	5-6	22		22-23	3	

WMSIII - Scaled-Score Equivalents of Raw Scores for Primary Index Subtest Scores: Age 14 (continued)

Scaled Score	LM II	FACES II	VPA II	Fam Pics II	Aud Rec	Digit span
19	28			64		
18	27			63		22
17	26	47-48		61-62		21
16	24-25	46		58-60	54	20
15	23	44-45		56-57	52-53	19
14	22	43		54-55	51	18
13	21	41-42		52-53	50	17
12	20	40	8	50-51	49	16
11	18-19	38-39	7	48-49	48	15
10	17	37	~	45-47	47	14
9	16	35-36	6	43-44	46	13
8	15	34	5	41-42	45	12
7	14	32-33	4	39-40	43-44	11
6	12-13	31	~	37-38	42	10
5	11	29-30	3	35-36	41	9
4	10	28	2	32-34	40	8
3	9	26-27	1	30-31	39	7
2	8	25		28-29	38	6
1	6-7	23-24		26-27	37	5

WMS-III - Scaled-Score Equivalents of Raw Scores for Primary Index Subtest Scores: Age 15

Scaled Score	LMI I	FACES I	VPA I	Fam Pic I	Let-Num	Spat Span
19	63-64	50-51	44-45	66-67	16	~
18	60-62	49	42-43	64-65	~	24
17	57-59	47-48	39-41	62-63	15	23
16	54-56	46	37-38	60-61	~	22
15	52-53	44-45	35-36	59	14	21
14	49-51	43	33-34	57-58	13	20
13	46-48	41-42	30-32	55-56	~	19
12	44-45	40	28-29	53-54	12	~
11	41-43	38-39	26-27	51-52	~	18
10	38-40	37	24-25	50	11	17
9	35-37	35-36	21-23	48-49	10	16
8	33-34	34	19-20	46-47	~	15
7	30-32	33	17-18	44-45	9	14
6	27-29	31	15-16	42-43	8	13
5	25-26	29-30	12-14	41	~	~
4	22-24	28	10-11	39-40	7	12
3	19-21	26-27	8-9	37-38	~	11
2	16-18	25	6-7	35-36	6	10
1	14-15	24	4-5	33-34	5	9

WMS-III - Scaled-Score Equivalents of Raw Scores for Primary Index Subtest Scores: Age 15 *(continued)*

Scaled Score	LM II	FACES II	VPA II	Fam Pic II	Aud Rec	Digit Span
19	43-44	49		66-67	~	25
18	41-42	47-48		65	57	24
17	39-40	46		63-64	56	23
16	37-38	45		61-62	55	22
15	34-36	43-44		59-60	54	21
14	32-33	42		58	53	20
13	30-31	40-41		56-57	52	19
12	28-29	39	8	54-55	51	18
11	25-27	37-38	~	52-53	50	17
10	23-24	36	~	50-51	49	16
9	21-22	35	7	49	48	15
8	19-20	33-34	~	47-48	47	14
7	17-18	32	6	45-46	46	13
6	14-16	30-31	~	43-44	~	12
5	12-13	29	~	42	45	11
4	10-11	27-28	5	40-41	44	10
3	8-9	26	~	38-39	43	9
2	5-7	25	~	36-37	42	8
1	3-4	23-24	4	34-35	41	7

APPENDIX B

Index Equivalents of Composite Scaled Scores: Age 12

Auditory Immediate		Visual Immediate		Immediate Memory		Auditory Delayed	
Sum	Index	Sum	Index	Sum	Index	Sum	Index
36	147	35	148	64	146	36	35
35	144	34	145	63	144	35	144
34	141	33	141	||	||	34	141
33	138	32	138	56	131	33	138
32	135	31	135	55	129	32	135
31	132	30	132	54	127	31	132
30	129	29	129	53	125	30	129
29	127	28	126	52	123	29	127
28	124	27	122	51	121	28	124
27	121	26	119	50	119	27	121
26	118	25	116	49	117	26	118
25	115	24	113	48	115	25	115
24	112	23	110	47	113	24	112
23	109	23	110	46	112	23	109
22	106	23	110	45	110	22	106
21	103	22	106	44	108	21	103
20	100	22	106	43	106	20	100
19	97	20	100	42	104	19	97
18	94	20	100	41	102	18	94
17	91	19	97	40	100	17	91
16	88	19	97	39	98	16	88
15	85	19	97	38	96	16	88
14	82	17	90	37	94	15	85
13	79	16	87	36	92	14	83
12	76	15	84	35	90	13	80
11	73	15	84	34	88	12	77
10	71	12	74	33	87	11	74
9	68	11	71	32	85	10	71
8	65	10	68	31	83	9	68
7	62	9	65	30	81	8	65
6	59	8	62	29	79	7	62
5	56	7	59	28	77	6	59
4	53	6	55	27	75	5	56
		5	52	26	73	4	53
				25	71		
				||	||		
				17	56		
				16	54		

Index Equivalents of Composite Scaled Scores: Age 12 *(continued)*

Visual Delayed		Auditory Recognition		General Memory		Working Memory	
Sum	Index	Sum	Index	Sum	Index	Sum	Index
35	146	20	150	64	123	36	147
34	143	19	145	63	121	35	144
33	140	18	140	||	||	34	141
32	137	17	135	59	115	33	138
31	134	16	130	58	113	32	135
30	131	15	125	57	112	31	132
29	128	14	120	56	110	30	129
28	125	13	115	55	109	29	126
27	122	12	110	54	107	28	123
26	119	11	105	53	106	27	120
25	116	10	100	52	104	26	117
24	113	9	96	51	103	25	115
23	110	8	91	50	101	24	112
22	107	7	86	49	99	23	109
21	104	6	81	48	98	22	106
20	101	5	76	47	96	21	103
19	99	4	71	46	95	20	100
18	96	3	66	45	93	19	97
17	93	2	61	44	92	18	94
16	90	1	56	43	90	17	91
15	87			42	89	16	88
14	84			41	87	15	85
13	81			40	86	14	82
12	78			39	84	13	79
11	75			38	83	12	76
10	72			37	81	11	73
9	69			36	79	10	70
8	66			35	78	9	67
7	63			34	76	8	64
6	60			33	75	7	61
5	57			32	73	6	58
4	54			31	72	5	55
				30	70	4	52
				29	69		
				28	67		
				27	66		
				26	64		
				25	62		
				||	||		
				21	56		
				20	55		

Index Equivalents of Composite Scaled Scores: Age 13

Auditory Immediate		Visual Immediate		Immediate Memory		Auditory Delayed	
Sum	Index	Sum	Index	Sum	Index	Sum	Index
5	52	5	54	19	55	3	50
6	56	6	57	20	57	4	53
7	59	7	60	21	59	5	56
8	62	8	63	22	61	6	59
9	65	9	66	23	63	7	62
10	68	10	69	24	66	8	65
11	71	11	72	25	68	9	68
12	74	12	76	26	70	10	71
13	78	13	79	27	72	11	73
14	81	14	82	28	74	12	76
15	84	15	85	29	76	13	79
16	87	16	88	30	78	14	82
17	90	17	91	31	81	15	85
18	93	18	94	32	83	16	88
19	97	19	97	33	85	17	91
20	100	20	100	34	87	18	94
21	103	21	103	35	89	19	97
22	106	22	106	36	91	20	99
23	109	23	110	37	94	21	102
24	112	24	113	38	96	22	105
25	116	25	116	39	98	23	108
26	119	26	119	40	100	24	111
27	122	27	122	41	102	25	114
28	125	28	125	42	104	26	117
29	128	29	128	43	106	27	120
30	131	30	131	44	109	28	123
31	134	31	134	45	111	29	126
32	138	32	137	46	113	30	128
33	141	33	140	47	115	31	131
34	144	34	143	48	117	32	134
35	147	35	147	49	119	33	137
				50	122	34	140
				51	124	35	143
				52	126	36	146
				53	128		
				54	130		
				55	132		
				56	134		
				57	137		
				58	139		
				59	141		
				60	143		
				61	145		

Index Equivalents of Composite Scaled Scores: Age 13 *(continued)*

Visual Delayed		Auditory Recognition		General Memory		Working Memory	
Sum	Index	Sum	Index	Sum	Index	Sum	Index
4	53	1	54	22	54	4	54
5	56	2	59	23	56	5	58
6	59	3	64	24	57	6	61
7	62	4	69	25	59	7	65
8	65	5	74	26	61	8	68
9	68	6	79	27	62	9	72
10	71	7	84	28	64	10	76
11	74	8	90	29	66	11	79
12	77	9	95	30	67	12	83
13	80	10	100	31	69	13	86
14	83	11	105	32	70	14	90
15	86	12	110	33	72	15	93
16	89	13	115	34	74	16	97
17	92	14	120	35	75	17	100
18	95	15	125	36	77	18	104
19	98	16	130	37	79	19	107
20	101	17	135	38	80	20	111
21	103	18	140	39	82	21	114
22	106	19	145	40	84	22	118
23	109	20	150	41	85	23	121
24	112			42	87	24	125
25	115			43	88	25	128
26	118			44	90	26	132
27	121			45	92	27	135
28	124			46	93	28	139
29	127			47	95	29	142
30	130			48	97	30	146
31	133			49	98		
32	136			50	100		
33	139			51	101		
34	142			52	103		
35	145			53	105		
36	148			54	106		
				55	108		
				56	110		
				57	111		
				58	113		
				59	115		
				60	116		
				61	118		
				62	119		
				63	121		
				64	123		

Index Equivalents of Composite Scaled Scores: Age 14

Auditory Immediate		Visual Immediate		Immediate Memory		Auditory Delayed	
Sum	Index	Sum	Index	Sum	Index	Sum	Index
6	54	7	51	22	54	5	55
7	58	8	55	23	56	6	58
8	61	9	59	24	59	7	61
9	64	10	63	25	61	8	64
10	67	11	67	26	64	9	67
11	71	12	70	27	67	10	70
12	74	13	74	28	69	11	73
13	77	14	78	29	72	12	76
14	81	15	82	30	74	13	79
15	84	16	85	31	77	14	82
16	87	17	89	32	80	15	85
17	90	18	93	33	82	16	88
18	94	19	97	34	85	17	91
19	97	20	100	35	87	18	95
20	100	21	104	36	90	19	98
21	103	22	108	37	93	20	101
22	107	23	112	38	95	21	104
23	110	24	115	39	98	22	107
24	113	25	119	40	100	23	110
25	117	26	123	41	103	24	113
26	120	27	127	42	106	25	116
27	123	28	131	43	108	26	119
28	126	29	134	44	111	27	122
29	130	30	138	45	113	28	125
30	133	31	142	46	116	29	128
31	136	32	146	47	119	30	131
32	139			48	121	31	134
33	143			49	124	32	137
34	146			50	126	33	141
				51	129	34	144
				52	132	35	147
				53	134		
				54	137		
				55	139		
				56	142		
				57	145		
				58	147		

Index Equivalents of Composite Scaled Scores: Age 14 *(continued)*

Visual Delayed		Auditory Recognition		General Memory		Working Memory	
Sum	Index	Sum	Index	Sum	Index	Sum	Index
6	54	1	59	28	55	4	55
7	57	2	63	29	57	5	58
8	61	3	68	30	59	6	61
9	64	4	73	31	61	7	63
10	68	5	77	32	64	8	66
11	71	6	82	33	66	9	69
12	75	7	86	34	68	10	72
13	78	8	91	35	70	11	75
14	82	9	96	36	72	12	78
15	85	10	100	37	74	13	81
16	89	11	105	38	76	14	83
17	92	12	109	39	79	15	86
18	96	13	114	40	81	16	89
19	99	14	119	41	83	17	92
20	103	15	123	42	85	18	95
21	106	16	128	43	87	19	98
22	109	17	132	44	89	20	101
23	113	18	137	45	91	21	103
24	116	19	142	46	94	22	106
25	120	20	146	47	96	23	109
26	123			48	98	24	112
27	127			49	100	25	115
28	130			50	102	26	118
29	134			51	104	27	121
30	137			52	106	28	124
31	141			53	109	29	126
32	144			54	111	30	129
33	148			55	113	31	132
				56	115	32	135
				57	117	33	138
				58	119	34	141
				59	121	35	144
				60	124	36	146
				61	126		
				62	128		
				63	130		
				64	132		
				65	134		
				66	136		
				67	139		
				68	141		
				69	143		

Index Equivalents of Composite Scaled Scores: Age 15

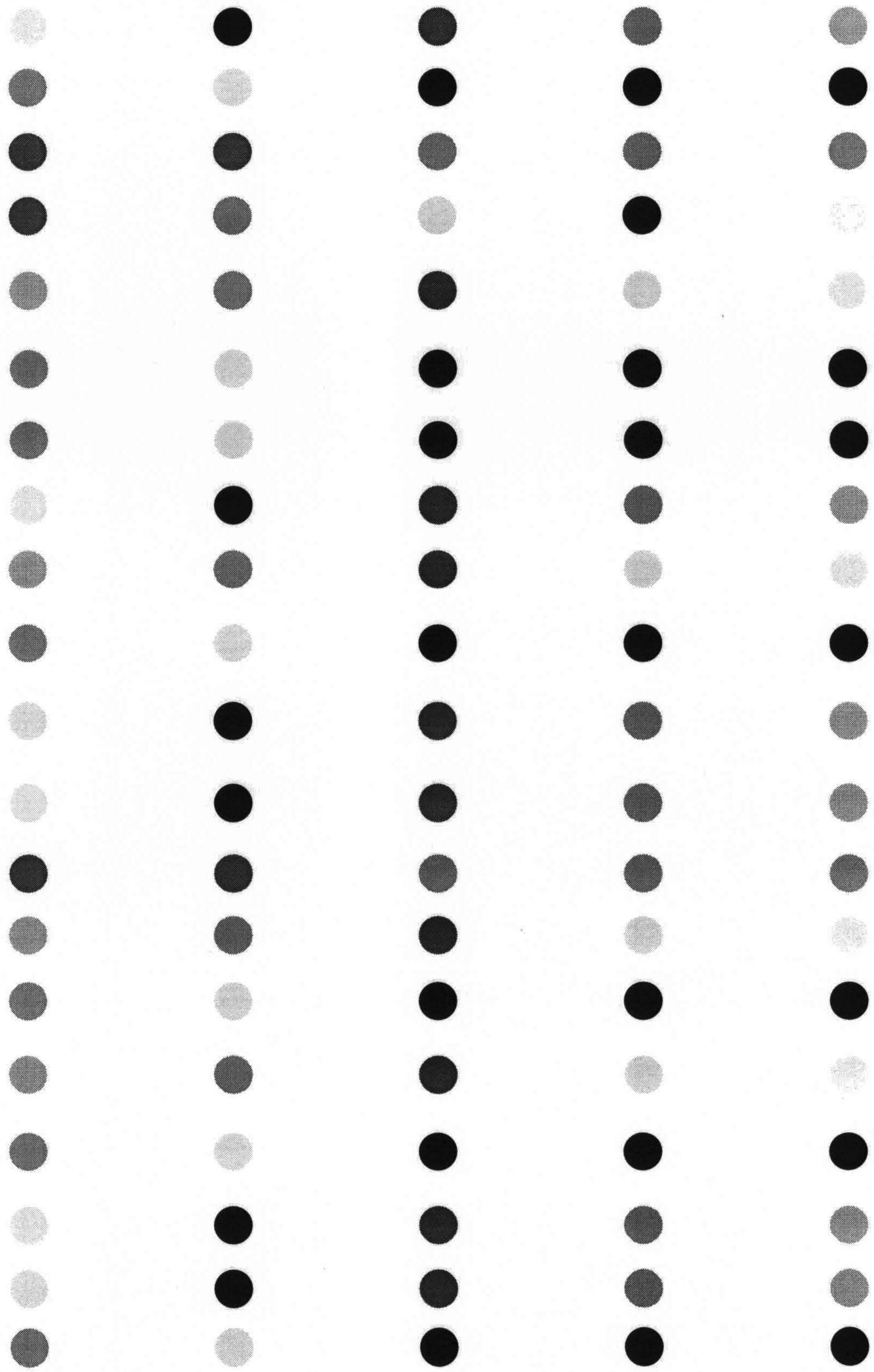
Auditory Immediate		Visual Immediate		Immediate Memory		Auditory Delayed	
Sum	Index	Sum	Index	Sum	Index	Sum	Index
7	54	6	55	18	53	5	54
8	57	7	58	19	55	6	57
9	61	8	61	20	58	7	60
10	65	9	65	21	60	8	63
11	68	10	68	22	62	9	66
12	72	11	71	23	64	10	69
13	75	12	74	24	66	11	72
14	79	13	78	25	68	12	75
15	82	14	81	26	70	13	78
16	86	15	84	27	72	14	81
17	89	16	87	28	75	15	85
18	93	17	91	29	77	16	88
19	96	18	94	30	79	17	91
20	100	19	97	31	81	18	94
21	104	20	100	32	83	19	97
22	107	21	104	33	85	20	100
23	111	22	107	34	87	21	103
24	114	23	110	35	90	22	106
25	118	24	113	36	92	23	109
26	121	25	117	37	94	24	112
27	125	26	120	38	96	25	115
28	128	27	123	39	98	26	118
29	132	28	126	40	100	27	121
30	135	29	130	41	102	28	124
31	139	30	133	42	104	29	127
32	143	31	136	43	107	30	130
33	146	32	139	44	109	31	134
		33	143	45	111	32	137
		34	146	46	113	33	140
				47	115	34	143
				48	117	35	146
				49	119		
				50	122		
				51	124		
				52	126		
				53	128		
				54	130		
				55	132		
				56	134		
				57	136		
				58	139		
				59	141		
				60	143		

Index Equivalents of Composite Scaled Scores: Age 15 *(continued)*

Visual Delayed		Auditory Recognition		General Memory		Working Memory	
Sum	Index	Sum	Index	Sum	Index	Sum	Index
5	52	1	54	24	53	8	54
6	55	2	59	25	55	9	57
7	58	3	64	||	||	10	61
8	62	4	69	30	64	11	65
9	65	5	74	31	66	12	69
10	68	6	79	32	68	13	73
11	71	7	84	33	70	14	76
12	74	8	89	34	71	15	80
13	78	9	94	35	73	16	84
14	81	10	99	36	75	17	88
15	84	11	105	37	77	18	92
16	87	12	110	38	78	19	95
17	91	13	115	39	80	20	99
18	94	14	120	40	82	21	103
19	97	15	125	41	84	22	107
20	100	16	130	42	86	23	110
21	103	17	135	43	87	24	114
22	107	18	140	44	89	25	118
23	110	19	145	45	91	26	122
24	113			46	93	27	126
25	116			47	94	28	129
26	119			48	96	29	133
27	123			49	98	30	137
28	126			50	100	31	141
29	129			51	102	32	145
30	132			52	103	33	148
31	136			53	105		
32	139			54	107		
33	142			55	109		
34	145			56	111		
				57	112		
				58	114		
				59	116		
				60	118		
				61	119		
				62	121		
				63	123		
				64	125		
				65	127		
				66	128		
				67	130		
				68	132		
				||	||		
				75	144		
				76	146		

APPENDIX C

Stroop Test



APPENDIX D

Predictive Inference Task

(Adapted from Lehman-Blake and Tompkins, 2001)

Story I (predictive inference = FISH)

RECENT

sl Tim set out his jacket and his cap.

s2 He had been looking forward to this trip for months.

s3 Tim had been busy at work and wanted some time alone.

p He put his rod in the car and drove to the lake.

DISTANT

sl Joe set out his gloves and his coat.

p He put his rod in the car and drove to the lake.

s2 He had been looking forward to this trip for a month.

s3 Joe had been busy at work and wanted a weekend alone.

CONTROL

s1 Don set out his coat and his hat.

s2 He had been looking forward to this trip for weeks.

s3 Don had been busy at work and wanted a few days alone.

He couldn't wait to go skiing by himself.

Story 2 (predictive inference = SWIM)

RECENT

S1 Patrick arrived at the event early Saturday morning.

s2 He had been preparing for the competition for several months.

s3 Patrick's teammates were cheering loudly.

p At the sound of the born, he dove into the water.

DISTANT

sl Andrew arrived at the competition early Saturday morning.

p At the sound of the horn, he dove into the water.

s2 He had been preparing for the event for a few months

s3 Andrew's teammates were clapping loudly.

CONTROL

sl Richard arrived at the competition early Friday morning.

s2 He had been preparing for the event for several months.

s3 Richard's friends were clapping loudly.

He ran faster than any of the other competitors

Story 3 (predictive inference = RAIN)

RECENT

sl Bill had been raking leaves all afternoon.

s2 He had only one more pile of leaves to collect.

s3 Bill quickly put them in his last garbage bag.

p There was a flask of lightning and a rumble of thunder.

DISTANT

sl Jeff had been raking leaves all afternoon.

p There was a flash of lightning and a rumble of thunder.

s2 He had only one more pile of leaves to pick up.

s3 Jeff hastily put them in his last garbage bag.

CONTROL

sl Fred had been raking leaves all morning.

s2 He had only one more pile of leaves to collect.

s3 Fred quickly put them in his last trash bag.

t The sun was shining as he tied the garbage bag.

Story 4 (predictive inference = SLEEP)

RECENT

sl Julie arrived home after midnight.

s2 She had worked the late shift in a noisy restaurant.

s3 Now Julie just wanted some peace and quiet.

p She climbed into bed and turned out the light.

DISTANT

sl Sally arrived home after midnight.

p She climbed into bed and turned out the light.

s2 She had worked the late shift in a noisy restaurant.

s3 Now Sally was ready for some peace and quiet.

CONTROL

sl Donna arrived home close to midnight.

s2 She had worked the late shift in a noisy hotel bar.

s3 Now Donna just wanted some peace and quiet.

She curled up under her blanket and read a book for two hours.

Story 5 (predictive inference = WRITE)

RECENT

Sl Jill had spent the day organizing her new desk.

s2 She wanted to let her brother know about her promotion,

s3 Jill knew he would be happy for her.

p She took out a piece of note paper and a pen.

DISTANT

s 1 Eve had spent the day organizing her new desk.

p She took out a piece of note paper and a pen.

s2 She wanted to let her brother know about her promotion

s3 Eve thought he would be happy for her.

CONTROL

sl Pam had spent the day organizing her new office.

s2 She wanted to let her brother know about her promotion.

s3 Pam knew He would be excited for her.

She called her brother and told him all about her new position.

Story 6 (predictive inference = SEW)

RECENT

sl Gina was almost finished with her Christmas presents.

s2 She had already made a handsome scarf for her brother.

s3 Gina also wanted to give her sister a special gift.

p She picked up a needle and thread and began to work.

DISTANT

sl Mary was almost finished with her Christmas presents.

p She picked up a needle and thread and began to work.

s2 She had already made a beautiful scarf for her father.

s3 Mary also wanted to give her sister a special gift.

CONTROL

sl Lori was almost finished with her Christmas presents.

s2 She had made a beautiful scarf for her father.

s3 Lori also wanted to give her mother a special gift.

She purchased a silk blouse and wrapped it in a large box.

Story 7 (predictive inference = SWEEP)

RECENT

sl Jane was cleaning house on Saturday.

s2 She had already worked most of the day.

s3 Now Jane had one more task to do.

p She went to the closet and took out a broom.

DISTANT

sl Ruth was cleaning house on Saturday.

p She went to the closet and took out a broom.

s2 She had already cleaned most of the house.

s3 Now Ruth had one lost task to do.

CONTROL

sl Beth was cleaning house on Thursday.

s2 She had already worked most of the day.

s3 Now Beth had one final task to do.

She dusted her bookshelves and then sat down to rest.

Note: s 1-3 = setting sentences; p = predictive sentence